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NUCLEAR TESTING ISSUES

HEARINGS

BEFORE THE

COMMITTEE ON ARMED SERVICES
UNITED STATES SENATE

NINETY-NINTH CONGRESS

SECOND SESSION

APRIL 29 AND 30, 1986

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NUCLEAR TESTING ISSUES

TUESDAY, APRIL 29, 1986

U.S. SENATE,
COMMITTEE ON ARMED SERVICES,
Washington, DC.

The committee met in executive session, pursuant to other business, at 4:08 p.m., in room SR-222, Russell Senate Office Building (Senator John W. Warner) presiding.

Present: Senators Goldwater, Warner, Quayle, Denton, Nunn, Stennis, Exon, Levin, Kennedy, and Dixon.

Staff present: Arnold L. Punaro, staff director for the minority; Robert F. Bott, Douglas R. Grahm, William, E. Hoehn, Jr., Judith A. Freedman, professional staff members; Colleen M. Getz, Russell C. Miller, research assistants; and Karen A. Love, staff assistant.

Also present: Gerald J. Smith, assistant to Senator Goldwater; Romie L. Brownlee, assistant to Senator Warner; James M. Bodner, assistant to Senator Cohen; Mark J. Albrecht, assistant to Senator Wilson, Allan W. Cameron, assistant to Senator Denton; Alan Ptak, assistant to Senator Gramm; Francis J. Sullivan, assistant to Senator Stennis; Janne E. Nolan, assistant to Senator Hart; Jeffrey B. Subko, assistant to Senator Exon; John B. Keeley, assistant to Senator Levin; Gregory B. Craig and Thomas K. Longstreth, assistants to Senator Kennedy; and Charles C. Smith, assistant to Senator Denton.

OPENING STATEMENT BY SENATOR JOHN W. WARNER, PRESIDING

Senator WARNER. The committee will come to order.

The Committee on Armed Services meets in closed session this afternoon to receive testimony from administration and public witnesses on the subject of nuclear testing limitations.

In view of the profound military implications of proposals to restrict U.S. nuclear testing activities, Chairman Goldwater, Senator Nunn, and I felt that it was important for the Committee on Armed Services to dedicate a separate hearing to this subject.

Today's hearing will help to formulate the record by which this committee will advise the Senate on the national security implications of this most important subject.

The issue of nuclear testing limitations has been discussed in this country for several decades. In 1963, the United States and the Soviet Union signed the Limited Test Ban Treaty that prohibited nuclear testing in the atmosphere, in outer space, and under water.

The Threshold Test Ban Treaty (TTBT) and the Peaceful Nuclear Explosions Treaty (PNET) were both signed in 1974. The Peaceful

Nuclear Explosions Treaty established a framework to govern underground nuclear tests for peaceful purposes. The Threshold Test Ban Treaty prohibited underground nuclear tests that exceeded a 150-kiloton threshold.

While the 1974 agreements have not been ratified by the Senate, both parties have agreed to observe the 150-kiloton threshold. However, as the administration has reported to Congress, the United States has concluded that the Soviet Union has violated the Limited Test Ban Treaty, and is likely in violation of the Threshold Test Ban Treaty.

In addition to these agreements, both the United States and the Soviet Union have committed themselves to the long-term objective of negotiating a Comprehensive Test Ban Treaty (CTBT). As the name would suggest, a Comprehensive Test Ban Treaty would prohibit nuclear testing altogether.

Upon entering office, the Reagan administration concluded that the Threshold Test Ban Treaty should not be ratified in its current form. This decision was based on their judgment that the treaty is not effectively verifiable. The administration has engaged in four separate initiatives over the past 2 years to resolve these verification concerns. However, the Soviet Union has failed to respond to these initiatives.

It is my hope, and the hope of others on this committee, that whatever action the Senate takes on the issue of nuclear testing, it will be designed to support the administration's efforts to resolve these verification problems. President Reagan has made it clear that if the Soviets will agree to an effective technical means of verifying the Threshold Test Ban Treaty, he is prepared to move forward in seeking the ratification of the TTBT and PNET agreements.

He has also made it clear that the United States remains committed to the long-term goal of a Comprehensive Test Ban. I look forward to today's hearing to elaborate on these issues.

The witnesses for our first panel this afternoon are Ambassador Kenneth Adelman, the Director of the Arms Control and Disarmanent Agency; Mr. Richard Perle, the Assistant Secretary of Defense for International Security Policy; and Dr. Robert Barker, who is currently the Deputy Assistant Director of the Bureau of Verification and Intelligence at the Arms Control and Disarmament Agency.

I would like to welcome you all on behalf of the committee.

At the conclusion of our panel of administration officials, the committee will convene a second panel with public witnesses. This panel will consist of Dr. Hans Bethe, Professor Emeritus at Cornell University; Dr. Donald Kerr, Senior Vice President of EG&G, Inc., and former director of the Los Alamos National Laboratory; and Dr. Alton Frye, Director of the Washington Office of the Council on Foreign Relations.

We are very pleased that these distinguished individuals were able to be with us as well.

Senator Nunn.

Senator NUNN. I will defer to the chairman if he has any statement.

Chairman GOLDWATER. I have no statement.

Senator NUNN. Chairman Warner, I appreciate your having these hearings. I think it is a very important subject. I think there is keen interest in this subject, both here in the committee and the Senate and the Congress and by the American people as well as internationally.

I see Mr. Perle here today. I have expressed my great concern about the published report regarding a book that he is supposedly in the process of selling the rights to.

I have written the President on that subject. I have not received a reply. I assume, but I do not know, that the administration is looking into this matter.

I know you have two panels of witnesses and once we start talking about concerns I have on that book, I think it would disrupt the whole hearing and we probably would end up without being able to get to the important matters that are here to be discussed, but, Mr. Chairman, I do not plan to raise that, but I want everybody to know that my question has not been answered and I have every concern I expressed in the letter which I have made public.

I have not heard from the administration on it. It is a matter of great public concern, I think, not just this particular matter, but the whole question about the obligation of public officials and what they can or cannot do while they are still in office.

I have great respect for Mr. Perle's knowledge, his expertise in the area of testing and area of national security. I know that he has spent a lot of his life in this field.

My concern is not related to his expertise, but whether indeed he can perform the high position of trust that he is now entrusted with and do it in a proper way, while at the same time be selling the rights to a book that no one knows the contents of, including those with whom he has to deal, both in our Government and in foreign governments.

So, the lack of questions in this respect, Mr. Chairman, does not in any way indicate my interest has in any way waned on this subject.

I would hope, first, to hear from the Executive Branch on what they are doing, which I have not heard from, and depending on that reply, I would hope that we would have a hearing on that subject.

So, I will not pursue that today.

I do congratulate the Chairman on bringing up this important subject. I think he has laid it out in his opening statement.

Senator WARNER. Thank you, Senator Nunn.

As you know, we discussed earlier the broad subject of this book. I personally talked to the Secretary of Defense this morning. I talked twice to Mr. Perle. I am satisfied, myself, that he has taken such steps in conversation with the Secretary of Defense which has enabled him to come forth on behalf of the administration today and maintain his credibility before this committee.

Senator NUNN. Unfortunately, I have not been so informed in any way. I have heard no reply. Although the letter is 2 weeks old, I have not received so much as an acknowledgement.

I am sure that the information you have, Mr. Chairman, is accurate. Whether it is or not, I am not going to pursue that subject

any further today, because I do think you have an important hearing here and you have a number of expert witnesses.

Senator WARNER. I appreciate the Senator's deferring the issue. Mr. Perle is prepared at such time as he and the Secretary of Defense feel appropriate to make a public statement on this subject. Since you have decided at this time you will not press further, I would prefer to go ahead with the hearing and then at some appropriate time, Mr. Perle, you and the Secretary can determine when it is in the interest of the Department of Defense to make such statement as you feel appropriate on this subject.

Senator EXON. Mr. Chairman, I congratulate you also for holding these hearings. I think they are tremendously important.

Before we begin, would it be out of order if I just asked these individuals who might be in a position to give us any information that they have with regard to the nuclear accident in the Soviet Union that we have heard quite a bit about since yesterday, whether or not there are any military implications or any other implications that would be proper to reveal to this committee.

Senator WARNER. I think we could do that. First, I would like to defer to Senator Levin if he has any preliminary remarks.

Senator LEVIN. No, Mr. Chairman.

Senator WARNER. The Senator from Michigan is one who suggested the hearing be held. He assisted the staff of the committee in selecting the witnesses on the panel.

Senator LEVIN. I simply want to thank the chairman of the subcommittee, the Chairman of the full committee, and Senator Nunn for moving ahead in this area. It is an important step for the committee to have hearings on this subject.

I hope, indeed, it is a first step. We cannot cover the subject in the time that we necessarily have had to allocate to it today.

I know that the Chairman will work with us to allow us to amplify the record with additional statements and materials so that the record can be more complete.

I assume and hope that the Chairman will work with us on adding items in the record which we feel are significant to make the hearing complete.

Senator WARNER. Senator, you have that assurance.

Before we begin, I want to insert for the record statements by Senators Kennedy and Dixon.

PREPARED STATEMENT OF SENATOR EDWARD M. KENNEDY

Mr. Chairman, I would like to express my appreciation to you for holding these hearings today on the very important issue of nuclear testing and test ban agreements. I would also like to thank our witnesses from the administration and our outside experts for joining us and giving us the benefit of their knowledge and insight into these issues.

We meet today at a time when the U.S.-Soviet nuclear and space talks in Geneva have apparently stagnated and the hope for arms control progress that followed last November's summit has receded. Those of us in the Congress who follow these negotiations continue to search for ways that a breakthrough might be achieved which could lead to an arms agreement reducing the risk of nuclear war.

One critical element of arms control since the United States and Soviet Union first began negotiating has been the issue of a ban on nuclear testing. Discussion between the two countries on a nuclear test ban began in the late 1950s, and the first major U.S.-Soviet nuclear arms agreement signed by the U.S. and USSR was the Limited Test Ban Treaty of 1963 which banned nuclear testing in the atmosphere, under water, and in outer space.

The news we have just received of a disastrous accident at the Soviet nuclear power reactor in Chernobyl should serve as a reminder to all of us of the tremendous danger to the health and safety of all inhabitants of the planet posed by large amounts of radiation in our environment. It should make even clearer the benefits we have derived from a ban on atmospheric nuclear testing these past twenty-three years.

Another objective that has eluded arms control efforts for the past several decades is a total ban on all nuclear testing. A comprehensive test ban treaty (CTBT) has been one of the most important and widely shared goals sought by every administration since Eisenhower—until this one. We have come very close on several occasions to achieving a total test ban, most recently in 1979, only to allow ourselves to become bogged down in political and bureaucratic disputes. It is the political obstacles to a CTBT—not technical ones—that have been allowed to stand in the way. This is a fact I find most disturbing.

I continue to believe that a CTBT would help lead us down the path to better security and a safer world. I do not accept the arguments of those in this administration who say that more testing allows us to develop "safer" and "better" nuclear weapons. This Administration has embarked on an unprecedented program to design, develop and test a grand assortment of new types of nuclear weapons, both strategic and tactical. Moreover, our nuclear scientists and weapon designers have found a new purpose for testing: to develop a nuclear-driven, anti-missile weapon to become part of President Reagan's so-called "non-nuclear" Star Wars Program.

I do not see how these developments will enhance our safety or our security. Testing will be used to develop new nuclear arms in ways that could erode deterrence and make these weapons more "usable" to decision-makers in a crisis. Moreover, not satisfied with the development and testing of the MX, Trident II and other weapons designs for the next generation of nuclear missiles, this administration is already beginning work on the follow-on generation. Where does it all end?

Another question needs to be asked, how does the development and testing of new generation of weapons, many of which would not even enter the stockpile until near the turn of the next century, fit in with the President's plan to rid the world of nuclear weapons, to make them impotent and absolete? I hope that our witnesses will be able to address this question.

Let me state, simply, why I believe a Comprehensive Test Ban to be in our national security interest.

First and foremost, a Comprehensive Test Ban Treaty would halt the development and testing of new types of more dangerous and destabilizing weapons for "Star Wars" and other questionable purposes.

Secondly, it would preserve the U.S. technological lead in the design of nuclear weapons and prevent the Soviet Union from designing new weapons with greater yield-to-weight and yield-to-volume ratios that would allow them to fit many more weapons on their existing missiles.

Finally, despite the statement of Mr. Perle and other Administration spokesmen to the contrary, a CTBT would *enhance* our efforts at preventing the spread of nuclear weapons to other nations. Under the Nuclear Non-Proliferation Treaty, the non-nuclear weapons states have agreed to forego the development of nuclear weapons in return for a pledge by the weapons states to pursue an end to the arm race, especially a CTBT.

I hope this Administration will reverse its current policy and resume negotiations to reach a CTBT. Both houses of the Congress have now voted overwhelmingly to ask the President to do just that.

At the very least, the President should move quickly to submit the Threshold Test Ban and Peaceful Nuclear Explosions Treaties for ratification. Ratification of these two treaties is the first step toward the goal of a comprehensive test ban treaty. Ratification would bring into effect verification provisions that the Administration claims are now lacking. Both agreements provide for exchanges of geological data and other information that would provide more accurate information about the size of Soviet tests.

The protocol to the PNET includes provisions for instrumentation equipment virtually identical to the CORRTEX method that the Administration is touting as a "breakthrough" in verification.

The arguments are overwhelming for moving ahead with ratification of the TTBT and PNET and resuming negotiations immediately on a CTBT. This Administration would send a strong message to the Soviet Union and to the world that it is serious about arms control if it would take these simple steps.

PREPARED STATEMENT BY SENATOR ALAN J. DIXON

Mr. Chairman, I look forward to hearing from the Under Secretary of Defense for Policy, Fred Ikle, and the Director of the Arms Control and Disarmament Agency, Kenneth Adelman, on nuclear testing issues.

Both of today's witnesses have excellent backgrounds in the arms control arena. This country has been involved in arms negotiations with the Soviet Union for over twenty years. Today we are in Geneva meeting again with the Soviets. I look forward to hearing about how these meetings are progressing.

Thank you, Mr. Chairman.

Senator WARNER. Now gentlemen, in such order as you may desire, can you enlighten the committee with respect to the tragic episode in the Soviet Union?

Mr. ADELMAN. Thank you, Mr. Chairman.

It is a pleasure to appear before you. Let me say a few things about Chernobyl and then whoever else would like to chime in, and we will move on to the issue of nuclear testing.

As I understand it, the accident probably occurred, at the latest, early Saturday. The Soviet government did not notify Sweden until Monday evening. By that time the Swedes had picked up the radioactive material at levels far above what was normal.

As I understand it, the Soviets are evacuating some 30 kilometers around the site right now. There is a lethal area at the site. The temperatures are some 4,000 degrees, or so, and the graphite is burning and will continue to burn for a good number of days.

As I understand it, there is not a whole lot that can be done about the burning except to just let it die down, which may take a number of days or even a week.

The concern is the pollution, of course, in the air, the wind direction, and the concern over water contamination because the site of the nuclear reactor is on the river. You have to presume, since the site is on the river, that the water level is relatively high, it is not too far from the ground to the water level right there.

The burning at the core, 4,000 degrees, is such a fantastic temperature that it would continue to go on even if the temperature settles down a little bit.

If it goes into the water, then you could have serious, serious contamination problems. That is not an official announcement or anything. It is just a concern that everybody would have at this point.

There seemed to be an explosion at the site and there are various theories on that. We have offered to help in every way we can.

Let me just leave it at that.

Senator WARNER. Mr. Perle.

Mr. PERLE. I have nothing to add.

Senator WARNER. As you point out, this would be burning for several additional days.

What form of pollution will be emitted? Is it a fluctuating one? Is the intense part of the pollution at the beginning of the burn, is it fairly level, or does it taper off?

Mr. ADELMAN. You have many different ingredients that cause the problem. What is the concern, more long-range concern, is radioactive iodine. It could get into the food chain and that is a concern in Scandinavia as well as the Soviet Union.

You have the biggest concern with plutonium and other material like that, but I could not give you a definitive answer, Mr. Chairman.

Senator WARNER. At an earlier date I asked the witnesses from the Department of Energy whether, in their judgment, and again working on the basis of hypothesis, would this pollution accumulate to such a magnitude that it could be transmitted to the continental United States and inflict any injury, bodily or otherwise.

Their answer was fairly direct in the negative.

Do you share that opinion?

Mr. ADELMAN. That is what I have been told as well. All these different elements have different half lives. Iodine has a half life of approximately 8 days. It will take some 6 days to go from the site to Scandinavian countries, for example.

So, it is just about almost at half potency by that time. Plutonium, of course, has a half life of 24,000 years. So, there is no real defense right there.

Chairman GOLDWATER. The graphite is used instead of water cooling?

Dr. BARKER. The type of reactor that has the problem is water cooled. The graphite is used to moderate the neutrons to improve the performance of the reactor, to make the reaction possible.

Senator EXON. What about the shift in the wind toward Poland and Eastern Europe?

Mr. ADELMAN. That could be a danger, depending on the shift in the wind, as you say, where it goes. So far it has gone to the area of Finland and Sweden and then, I understand today, there has been a wind shift. The biggest concern in the Soviet Union is that the wind shift would be toward the direction of Kiev.

Senator EXON. South to Kiev?

Mr. ADELMAN. Southeast. That would be the biggest danger because Kiev is a city of about 2½ million people, the capital of the Ukraine.

Senator STENNIS. You say 2½ million people in the danger zone?

Mr. ADELMAN. No, I would not say that.

Senator STENNIS. What did you say?

Mr. ADELMAN. I would say if the wind shifts, the biggest problem would be the wind shifting to contaminate the air around Kiev and Kiev is a city of 2½ million.

Senator EXON. It is rather close; is that right?

Dr. BARKER. It is about 60 miles, I believe.

Mr. ADELMAN. You have an air danger for Kiev and you have a water danger if the core should burn down to the water level. I have no information that it is.

Senator STENNIS. Do you have an estimate of the number of people who are endangered there now?

Mr. ADELMAN. We do know that there were estimated to be around 2,000 people in the village that was constructed for the nuclear reactors themselves. All those people obviously are in severe danger. There may be casualties. The Soviet Union has announced, I think, two casualties which seems preposterous.

I say that is fairly preposterous in terms of an accident of this magnitude. Those 2,000 would be at the point of danger. Then you have a 30-kilometer radius that has been evacuated now.

Senator WARNER. What would the temperatures be within that radius?

Dr. BARKER. I think it is fairly close to normal. The heat of the burning graphite will be very localized to the area of the reactor burn.

Senator WARNER. Then the primary contingency for damages to the air pollution and somehow getting into the water supply, is that through air pollution?

Dr. BARKER. Air pollution and contamination of the water supply. I do not know whether there is much agriculture in the environment. Certainly there is a danger of radioactive pickup in any agriculture in the region.

Senator WARNER. That is primarily an agriculture region?

Mr. ADELMAN. Yes, and the iodine could get into the food cycle. Cows can eat it and then it is in the milk.

Senator EXON. Of course, they have to worry about the water downstream from Kiev.

Mr. ADELMAN. That is a concern. We have no information on that. I am just saying that the logic of the situation is that when you have this core burning at 4,000 degrees, or so, it is going to go down, down, down. If it hits the water level, then you have serious problems of contamination.

You can presume that Kiev relies almost entirely on the water from that river.

Senator WARNER. Gentlemen, thank you very much for that analysis.

We will now hear from the Ambassador on nuclear testing issues.

STATEMENT OF HON. KENNETH L. ADELMAN, DIRECTOR, ARMS CONTROL AND DISARMAMENT AGENCY

Mr. ADELMAN. Thank you.

Mr. Chairman, let me summarize my statement. I ask your good permission to put my full statement in the record.

Senator WARNER. Without objection.

Mr. ADELMAN. Basically, the administration's point of view is that a CTB is not in our national interest right now.

Senator WARNER. I would use the full term and then get down to the abbreviation.

Mr. ADELMAN. I am sorry?

Senator WARNER. What is not in the national interests?

Mr. ADELMAN. The Comprehensive Test Ban is not in our national interest right now under the conditions prevailing in the world today. This is simply because nuclear testing is required for the reliability and safety of nuclear weapons on which our security and our deterrent posture ultimately depends.

I think it would be, in my own mind, fair to say that those who advocate a Comprehensive Test Ban would have two premises of their argument.

One I believe is true and one is not. The one that would be true is that the purpose of a Comprehensive Test Ban would be to appear to strangulate the progress and development of nuclear weapons in the future. I think a case can be made for that.

The one premise that is not true, I do believe, is that strangulation of nuclear weapons development in the future would necessarily be a good thing and increase the safety of our alliance and our country.

I think there has been progress in nuclear weapons development over the years to make them much safer than they have been in the past, the reliability is much higher than it has been in the past, and, consequently, has enabled us to reduce the number of nuclear weapons substantially over the years.

Today we have about one-fourth fewer nuclear weapons in the arsenal than we had in the 1960's, and some 70 percent less megatonnage or yield than we did right then.

Senator WARNER. Seventy percent less megatonnage than in the 1960's.

Mr. ADELMAN. In the late sixties; that is correct.

We have been able to do that, in large part, because of the increase in reliability and safety of nuclear weapons. I know that NATO, through the good work of Secretary Perle and others, has reduced the number of tactical nuclear weapons in Western Europe by some 2,400 over the last 5 years.

That, too, is possible because of the advantages that testing gives us. I think, as the statement says, on the Threshold Test Ban and the Peaceful Nuclear Explosion Treaty, as you mentioned, Mr. Chairman, we have found that there are likely Soviet violations over the years. We have found in this administration that the verification methods have been inadequate for those treaties, and we have gone to the Soviets time, and time, and time again to get better verification, and have been rebuffed each time.

We asked the Soviets, starting in 1983, to discuss better verification, protocols, annexes, or agreements on those two treaties. We went back in 1984, as I remember, Mr. Chairman, with an invitation to visit test sites on each side.

In mid-1985 the President decided on a unilateral invitation to the Soviets. In December 1985 we urged that our experts meet on the subject.

In March 1986 we said that we would be happy to move forward toward ratification of the TTBT and PNET if we could get good verification going. We invited the Soviets to come to a U.S. test the third week in April to look at the CORRTEX capability and to start the process there.

I think it is fair to say that we have really gone the extra mile, to use a hackneyed expression, to get the Soviets' attention on the Threshold Test Ban Treaty and the Peaceful Nuclear Expolsion Treaty.

I think, myself, it becomes unseemly after a while to come up with proposal after proposal to the Soviets who will not even talk to us about better verification. If there is anything I have learned from this committee and from the Senate, in general, over the years, it is that the Senate as a body and this committee, in particular, feel very strongly that the verification and arms control should go hand in hand and we should not, in this administration or any other, bring up an unverifiable treaty.

I think that the task before us is the same task as in 1983, to convince the Soviets to fix the treaty, to have better verficiation provisions to it, and to get to work on that.

Let me just end up where I began. It is interesting to me in the arms control business that verification is a problem that we have in dealing with the Soviet Union. It is not necessarily or it is not at all, to my mind, the problems the Soviets having in dealing with us.

We are a very open society. We have an independent Congress, independent press, independent interests groups, a tremendous public that can go and investigate many things. It is inconceivable in a society like this that a nuclear accident that was by far the greatest nuclear accident in history, of the magnitude we have discussed before, could happen on Friday night or Saturday morning and not be announced to the world until Monday night, and only then because the Swedes and the Finns picked up the radioactive material.

This is the kind of society we are operating with in the Soviet Union. They cannot even go for help to the outside world in a catastrophe like the nuclear plant explosion because of their tremendous secrecy and their tremendous closed nature.

So, I think what we have to do is have patience to wait until the Soviets agree to give us good verification and then to proceed ahead. I think it would be a great mistake to knock ourselves out and to keep pleading with the Soviets to do that.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Adelman follows:]

PREPARED STATEMENT OF KENNETH L. ADELMAN, DIRECTOR, U.S. ARMS CONTROL AND DISARMEMENT AGENCY ON NUCLEAR TESTING LIMITATIONS

Many in Congress today are interested in nuclear testing limitations: namely, in a comprehensive test ban (CTB) and in ratification of the 1974 Threshold Test Ban Treaty (TTBT) and the Peaceful Nuclear Explosions Treaty (PNET). Significantly different issues are involved in each. Therefore, I would like to treat them separately.

A comprehensive test ban remains a long-term objective of the United States. We believe such a ban must be viewed in the contesxt of a time when we do not need to depend on nuclear deterrance to ensure international security and stability, and when we have achieved broad, deep, and verifiable arms reductions, substantially improved verification capabilities, and greater balance in conventional forces.

As long as we must rely on nuclear weapons for deterrence, nuclear testing will continue to be required. Nuclear testing is required for the reliability, safety and survivability of our nuclear forces, to ensure the survivability of non-nuclear forces and command-and-control, and also for modernization. It is critical that we be able to continue to modernize to respond to Soviet modernization and other activities which diminish the credibiliity of our deterrent.

Verification of a comprehensive test ban also poses tremendous problems. While our ability to detect nuclear explosions by seismological means has greatly-through enormous effort—improved, we still cannot distinguish at low—but militarily significant yields—a nuclear explosion from other seismological events such as earthquakes or chemical explosions.

In the nuclear testing area, the United States places a high priority on improved verification of the 1974 Threshold Test Ban Treaty (TTBT) and the 1976 Peaceful Nuclear Explosions Treaty (PNET). The United States has observed the 150 kiloton threshold of the TTBT since 1976, but has not ratified it. The Soviet Union has stated that it would observe the 150 kiloton threshold—but as the President's reports on compliance make clear, the Soviets have likely violated this limit.

Some argue that the verification provisions of the TTBT, which would come into effect with the ratification of the treaty, are adequate to verify the level of Soviet testing. These claims are not accurate. The TTBT and its associated Protocol con-

tain provisions for the exchange of geophysical data and for announcing the yields of two explosions for calibration purposes. But the Treaty provides no mechanism for one Party to validate independently the accuracy of the data provided by the other Party.

Data provided on two Soviet tests would be of little value unless it can be independently verified by the United States. And even if the particular data exchanges were accurate, that data is limited and would not reduce the overall uncertainty in the seismic yield estimation process to acceptable levels.

Additional verification measures are included in the PNET since it involved explosions conducted away from military test sites and permitted aggregates of multiple tests to be above 150 kilotons. Provisions were, therefore, included for on-site measurements of each explosion by downhole instrumentation similar in result to the current CORRTEX equipment. Seismic instruments were also to be allowed in the test area to detect non-standard explosive emplacement or hidden explosives. However, even if the PNE Treaty had been ratified, this does not solve the problem of the TTBT. Moreover, these PNET verification measures would not have been implemented up to now because the Soviets have apparently never reached the yield threshold for PNEs that would trigger installation of U.S. devices on Soviet territory.

As you are aware, the United States has made several specific suggestions to the Soviet Union aimed at ensuring effective verification of the TTBT and PNET.

In 1984 President Reagan proposed an exchange of Soviet and U.S. experts to measure directly the yields of tests of nuclear weapons at each other's test sites. In mid-1985, the President unconditionally invited Soviet experts to measure such a test at the Nevada Test Site, bringing with them any instrumentation devices they deemed necessary for such measurement.

In December, 1985, the President proposed to Secretary General Gorbachev that U.S. and Soviet experts on nuclear testing limitations meet in February, 1986, to discuss our respective verification approaches and to address initial tangible steps to resolve this issue. On March 14, 1986 the President proposed that the Soviet Union join the United States in bilateral discussions on finding ways to reach agreement on essential verification improvements of the TTBT and PNET. The President invited Mr. Gorbachev to send his scientists to the U.S. test site the third week of April, 1986 to monitor a planned U.S. nuclear weapons test and to examine the CORRTEX system. The President stated that, if the Soviets would join us in an agreement for effective verification, including the use of CORRTEX, the United States would be prepared to move forward on ratification of the TTBT and the PNET.

To date the Soviet Union has not responded either to the serious U.S. concerns in this area or to any of our initiatives to address these concerns in a constructive manner.

Our verification concerns cannot be satisfied by appending them to requests to the Senate for advice and consent on treaty ratification. They can only be satisfied by an honest exchange of technical views with the Soviets, as we have repeatedly proposed, on how verification can be improved and subsequent negotiation with the Soviets on the means which will permit effective verification.

Ratification without such verification improvements would provide no guarantee of their subsequent adoption. We need to fix the treaty before, not after we ratify. Failure to do so will only fuel future acrimony.

The United States seeks to achieve the eventual elimination of nuclear weapons in a way that strengthens the security and stability which the entire world desires. In this context, we are convinced that deep reductions in the offensive nuclear weapons of the Soviet Union and the United States must have our highest priority. In seeking deep reductions we will demand equality and require effective verification in any resultant treaty. Congressional support for U.S. efforts to achieve such reductions in the Geneva negotiations has been substantial and we believe such support is not lost on the Soviets.

Senator WARNER. We will now hear from Mr. Perle.

STATEMENT OF HON. RICHARD PERLE, ASSISTANT SECRETARY OF DEFENSE FOR INTERNATIONAL SECURITY POLICY

Mr. PERLE. Thank you, Mr. Chairman.

I, too, will be brief and refer to only part of my prepared statement.

Senator WARNER. Without objection, it will be included in the record.

Mr. PERLE. Under present circumstances, Mr. Chairman, we see no practical or acceptable alternatives to nuclear deterrence as the essential means of providing for our security. Therefore, for the foreseeable future nuclear weapons will continue to be the key element of our deterrent. In such a situation, where we must rely on nuclear means to deter aggression, nuclear testing will continue to be required.

Senator LEVIN. Do we have copies of the witnesses' statement?

Senator WARNER. Presumably they have been given to the committee.

Senator LEVIN. Mr. Chairman, they have not been submitted at all. The last statement was submitted today. We are supposed to have them 48 hours in advance of the hearing.

Senator WARNER. The Senator raises a valid point.

Senator LEVIN. This statement, we do not have it at all.

Senator WARNER. You brought it with you, Mr. Perle?

Mr. PERLE. I did bring it; yes.

Senator WARNER. Did you have the statement in advance?

Senator LEVIN. Not 48 hours in advance. I do not quarrel about that.

Mr. PERLE. I apologize, Senator Levin.

Senator WARNER. Is it possible since you are working from an addendum to your statement, the statement could be duplicated?

Mr. PERLE. Actually, I was reading from the statement, but certainly the statement can be duplicated.

Senator WARNER. You know it by heart. Mr. Perle, you are at your best when you are on your own.

Mr. PERLE. Senator, the essence of our interest in continued testing is that a variety of functions critical to maintaining our nuclear deterrent depends on being certain that the weapons in our inventory are reliable, safe, and that they incorporate the most effective features that make them safe and effective that we can develop.

So, the process over the years has been one of continuous development and modernization of the nuclear weapons in the stockpile.

I believe it is fair to say that had we embarked on a comprehensive test ban at those earlier periods when it was urged upon us, as it is being urged upon us today, we would have frozen our inventory of nuclear weapons in a manner that would not have contributed to our security and would, in fact, have required the maintenance of a larger stockpile of weapons with significantly greater yield.

I think the point that my colleague, Ken Adelman, was getting at in indicating that we have reduced the stockpile by some 70 percent in megatonnage since the mid-1960's and by some 8,000 weapons total, the ability to do that was based on the evolution of the smaller residual force and the greater effectiveness of individual weapons.

If we had frozen our technology in the mid-sixties, we would have weapons with vastly greater yields than was necessary in order to accomplish our military missions. With that additional yield comes unnecessary collateral damage.

Had we frozen our stockpile earlier, as we were urged to do, we could not have incorporated some of the fundamental safety features that virtually reduced to zero the likelihood of an accidental nuclear detonation.

So, the evolution of the stockpile is important in maintaining the effectiveness and the safety and the security and survivability of the nuclear deterrent on which we depend.

Now, it is often claimed, quite wrongly, that the only critical reason for the testing of nuclear weapons is in order to develop new ones. While we do indeed conduct developmental tests in order to prove the effectiveness and workability of new nuclear weapon designs, we are also necessarily vitally interested in the ability of our weapons to survive in the face of nuclear weapons that might be directed against them.

A key part of our testing progam entails the exposure to nuclear effects of components and even whole weapons systems on which we depend. In short, we need to know whether the electronic devices in our weapons would survive a nuclear attack.

As we seek to reduce the vulnerability of our weapons to nuclear attack, we need to be able to test the improving and evolving technologies in real tests in which exposures to levels of radiation and other nuclear effects associated with real nuclear blasts can be accomplished.

We hear many different opinions from within the scientific community on the need for testing. The administration in this regard can only be guided by those who are legally responsible for the design, development, and certification of U.S. nuclear weapons, the fellows who have to sign to the effect that a weapon that is going into the inventory is in fact adequate and safe.

These are the directors of our national weapon laboratories. Without exception, they have been unequivocal on the need to test so long as the United States relies on credible deterrence based on nuclear weapons.

Some of the experts who claim that the nuclear stockpile can be maintained without nuclear explosive testing were in fact in charge of the stockpile during the period of 1958 to 1961 moratorium.

The moratorium, the committee will recall, was broken when the Soviet Union conducted a massive series of tests which was lead by the largest nuclear test ever conducted, a 58-megaton weapon detonated by the Soviet Union in 1961, on the eve of the Conference of Non-Aligned Nations, meeting in Indonesia.

But that period, the 1958 to 1961 period was one in which some of the most serious realiability problems we have ever experienced developed within our nuclear stockpile. One wonders how experts who now say we can dispense with testing have so soon forgotten the experience of that 3-year period when some weapons introduced into the inventory and considered to be effective and safe but were not tested later were found to be unsafe, only partially functional, or in some cases inoperable.

Now, we all desire stabilizing arms control agreements with the Soviet Union that will diminish the threat to this country and its allies and permit us to maintain an adequate and survivable deterrent at significantly lower levels of weapons. But of all the ways

that we should attempt to achieve that result, it seems to us that the least prudent, as we continue to maintain a large arsenal of nuclear weapons, is to cease the testing of those nuclear weapons, terminate the future development and refinement of those weapons so as to enable us to reduce the stockpile, both in terms of the numbers of weapons and their yield, and to terminate the effort to make the weapons as safe as we can possibly make them.

Of all the ways in which a nuclear disaster might occur, it seems to some of us that perhaps the most likely, unlikely though it is, is through an accident of some sort, not through a deliberate decision to launch a worldwide nuclear war.

Everything that can be done to diminish the likelihood of an accident must be done and that, unfortunately, requires testing in real world circumstances. We will go on with the requirement for that sort of testing until we reach the point where we no longer depend on nuclear weapons for our defense.

Senator WARNER. An example of that theory is what we are witnessing today in terms of a civilian powerplant. There was undoubtedly an accident.

Does that serve as an example of what you are advancing today?

Mr. PERLE. It is certainly a reminder of the consequences of even a single accident.

When one weighs the benefits of a comprehensive test ban, if it can be made verifiable and we do not believe we could, against the consequences of an accident that might have been prevented had a weapon design been adequately tested or had a weapon in the stockpile been tested periodically to assure that it would not malfunction, it seems to me prudence dictates that we continue testing and seek to achieve stability in our realtionship with the Soviet Union through the many other approaches to arms control that are now underway.

[The prepared statement of Mr. Perle follows:]

PREPARED STATEMENT BY HON. RICHARD N. PERLE, ASSISTANT SECRETARY OF DEFENSE (INTERNATIONAL SECURITY POLICY)

Good afternoon ladies and gentlemen. I am pleased to appear before the Senate Armed Services Committee on behalf of the Department of Defense to discuss the national security requirements for nuclear testing and the military implications of nuclear test bans. I would like to begin by placing both in a historical context.

HISTORICAL CONTEXT

The concept of a nuclear test ban is one of the oldest in arms control. On April 2, 1954, Prime Minister Nehru of India proposed a "standstill agreement" on nuclear weapon testing. Other leaders of that era also proposed a cessation of nuclear weapon testing, generally as part of more comprehensive proposals on disarmament.

Within the United States, test bans were viewed as an element of a broad spectrum of arms control objectives. President Eisenhower for example, believed that the main issue was not the cessation of testing of nuclear weapons, but the prevention of their use in war. Hence, his efforts were focused on such measures as reduction in armaments—both nuclear and conventional, safeguards against the possibility of surprise attack and cutoff of production of fissionable materials for weapon purposes. He also insisted that any arms control proposals must meet one fundamental test: There must be effective verification measures to ensure compliance of all nations and to give adequate warning of possible evasions or violations.

On May 10, 1955, the Soviet Union proposed a test ban as one of the first steps in a phased reduction of conventional forces and elimination and prohibition of nuclear weapons. Subsequently, on February 14, 1956, Chairman Khrushchev before the 20th CPSU Congress in Moscow stated, "We are willing to take certain partial

steps—for example to discontinue the thermonuclear weapon tests. * * *" On September 11, 1956, Premier Bulganin proposed in a letter to President Eisenhower a separation of the problem ending weapon tests from the general problem of disarmament, and on December 10, 1957, he proposed that a (2 to 3 years) moratorium on nuclear testing take effect on January 1, 1958.

On March 31, 1958, following a major test series, the Soviet Union unilaterally suspended nuclear testing and called on the U.S. and the UK to join. However, the U.S. and UK believed that this proposal for an uninspected test ban was intended to place them at a military disadvantage and prevent them from beginning a test series that had been announced. Hence, they refused. In a subsequent exchange of letters, Chairman Khrushchev and President Eisenhower agreed to a meeting of technical experts to study the problems associated with verification of a nuclear test ban.

The technical experts issued their export on August 21, 1958. They concluded that it was technically feasible to establish with then current capabilities and limitations, a workable and effective control system to detect violations of an agreement on a worldwide suspension of nuclear weapon tests.

On the very next day, President Eisenhower proposed negotiations for a comprehensive test ban to be verified by the system proposed by the technical experts. He also expressed willingness to suspend testing for one year on a renewable basis, beginning with the opening of negotiations on October 31, 1958.

Three unilateral, voluntary pledges to suspend testing followed—by the U.S. and the UK in 1958, and by the USSR in 1959. These suspensions amounted to a de facto moratorium. There was, however, no joint formal agreement. At the end of 1959, President Eisenhower, angered by Soviet intransigence on verification issues in the then ongoing test ban negotiations, announced that the U.S. was no longer bound by its voluntary moratorium. But he also said that the U.S. would continue its "voluntary suspension," in effect continuing the U.S. moratorium. After Eisenhower's announcement, Khrushchev stated that the USSR would not resume testing until the "Western Powers" did so. The context of this and earlier Soviet statements clearly indicates that the Soviet Union was referring to a resumption of testing by the U.S. and the UK—the only Western powers that had tested.

On February 13, 1960, France conducted its first nuclear test and its fourth on April 25, 1961. On May 15th, the Soviets announced that "if France continues" testing, the USSR would be compelled to test.

The Soviets resumed testing on September 1, 1961 with the most intensive test series in history, although France did not conduct another test, nor had the U.S. and UK resumed testing. Thus, the Soviets broke their own pledge of 1959 as well as the de facto moratorium on nuclear testing, using French testing as a pretext.

Indeed, Mr. Khrushchev in an unusually candid interview on the eve of the breakout told British Parliamentarians that he had decided to resume testing—including a bomb of unprecedented proportions (58 MT)—to shock the Western powers into negotiations on his terms on Germany, and into merging Geneva test-ban negotiations with those on complete and general disarmament. Khrushchev did not achieve his objectives.

Although some today question whether a moratorium existed at the time. President Kennedy certainly believed that one was in effect and that the Soviets broke it. In a radio address to the nation on March 2, 1962, he stated, "On September first of last year, while the United States and the United Kingdom were negotiating in good faith at Geneva, the Soviet Union callously broke its moratorium with a two-month test series of more than 40 nuclear tests. Preparations for these tests had been secretly underway for many months. . . ."

In 1963, however, the U.S. and USSR reached agreement on the Limited Test Ban Treaty (LTBT), which prohibits nuclear testing in all environments except underground. That Treaty permits underground testing only if such tests do not release radioactive debris which goes beyond the national territory of the testing party.

I believe that it was during the LTBT ratification hearings that the first comprehensive examination of the national security implications of testing limitations occurred at the national level, and the need for testing was recognized. President Kennedy took these concerns into account and built a consensus for ratification of the LTBT around Safeguards. The Safeguards provide for the conduct of comprehensive, aggressive, and continuing underground nuclear test programs to add to our knowledge and to improve our weapons in all areas of significance to our military posture for the future. The Safeguards also require maintenance of modern nuclear laboratory facilities and programs in theoretical and exploratory nuclear technology to ensure continued progress in that technology. In part, the Safeguard concept result-

ed from our experience during and immediately after the 1958–61 moratorium, which included serious reliability problems with the nuclear stockpile.

Subsequent Administrations have maintained the key Safeguards in order to assure that the U.S. deterrent capability remains strong and effective. This was the policy of President Carter, who actually engaged in negotiations on a CTB, as well as other Presidents. There is no doubt that he, as well as his predecessors, fully appreciated that the security of the United States, its allies, and its friends depends upon a credible and effective nuclear deterrent.

CURRENT REQUIREMENTS

What are the requirements today? Under present circumstances, I see no practical or acceptable alternatives to nuclear deterrence available to us for providing for our security. Therefore, for the foreseeable future, nuclear weapons will continue to be the key element of our deterrent. In such a situation, where we must rely upon nuclear weapons to deter aggression, nuclear testing will be required.

Only through continued nuclear testing can we ensure that our warheads and weapon systems are safe and secure; that they are reliable and effective; that they could perform their military missions, if required, with as little collateral damage as possible; and perhaps most important for the stability of deterrence, that the weapon systems themselves are survivable. Nuclear testing also is necessary to develop modernized weapons in response to new and evolving Soviet threats. This is especially crucial in the face of the unprecedented Soviet buildup in nuclear capability over the last 15 years as well as their extensive strategic defense efforts. In short, continued nuclear testing is essential to a credible nuclear deterrent.

Although we hear many different opinions from the scientific community on the need for testing, the Administration can be guided only by those who are legally responsible for the design, development and certification of U.S. nuclear weapons—the directors of the national weapon laoratories. And they have been unequivocal on the need to test as long as the U.S. relies upon a credible nuclear deterrent for security. Ironically, some of the so-called "experts" who claim that the nuclear stockpile can be maintained without nuclear explosive testing were in charge of the stockpile during the 1958–61 moratorium, a period which saw some of the most serious reliability problems our stockpile every had. How can they forget the mistakes made during that period in the absence of testing? We cannot help but recall that some weapons placed into the stockpile after what was considered adequate testing were later found to be unsafe, partially functional, or inoperable.

The Soviet Union would gain unilateral military advantages under a CTB. Available evidence indicates that we almost certainly depend more on high technology in warhead design and, consequently, more on continued nuclear testing. In addition, given our inability to verify a cessation of nuclear testing, the Soviets could test at militarily significant yields with little risk of detection. Such testing would allow them to retain confidence in the reliability of their stockpile, retain the viability of their technology base, and possibly design some new weapons. Hence, the Soviet Union could retain a credible nuclear capability during a CTB while U.S. capabilities eroded.

Even if Western and Soviet nuclear capabilities were to erode symmetrically under a CTB, the Soviet Union would still be in a dominant position. In such a situation, we would be hard pressed to deter Soviet aggression in the face of superior Soviet strength in conventional forces and chemical weapons, and possibly unilateral biological/bacteriological capabilities.

Given the reliance of the free world on nuclear weapons to deter aggression, a CTB at this time could encourage the retention and proliferation of nuclear weapons. Nuclear weapons states could be expected to hedge against possible reliability problems by increasing the number and yield of warheads in their respective stockpiles. Non-nuclear weapon states who did not have to address the question of an independent nuclear capability because of U.S. nuclear guarantees, would have to reassess their requirements for national security, should they lose confidence in the U.S. nuclear deterrent. Under these circumstances, the nuclear option cannot be excluded. Hence, a CTB could lead to a less safe and far more dangerous world than we have today.

In sum, I believe that contrary to the assertions of some, there is historical consistency in the position of the Reagan Administration that a CTB must remain a long-term objective of the United States. We believe that such a bank must be viewed in the context of a time when we do not need to depend on nuclear deterrence to ensure international security and stability, and when we have achieved broad, deep, and verifiable arms reductions, substantially improved verification ca-

pabilities, enhanced confidence-building measures, and greater balance in conventional forces.

Senator WARNER. We will now hear from Dr. Barker.

STATEMENT OF DR. ROBERT BARKER, DEPUTY ASSISTANT DIRECTOR, BUREAU OF VERIFICATION AND INTELLIGENCE, ARMS CONTROL AND DISARMAMENT AGENCY

Dr. BARKER. I am very happy to appear before the committee this afternoon to touch on some of the technical foundations for the administration's views on nuclear test limitation treaties.

Senator, I would like to submit my formal comments for the record and summarize them very briefly.

Ambassador Adelman and Mr. Perle have summarized the policy context of our current position with respect to both the Threshold Test Ban Treaty and a comprehensive test ban.

I want to quote briefly from a recent letter from the President to Senator Dole in which the President pointed out the comprehensive test ban does remain a long-term goal of the United States, but one which must be acheived in the context of substantially improved verification capabilities and at a time when a nuclear deterrent is no longer an essential element, as currently, for international security and stability.

Nuclear testing assures that our weapons today are safe, effective, reliable, and survivable. Nuclear testing also assures our capability to respond to continued Soviet nuclear arms buildup.

Nuclear tests fall into four basic categories. They have already been referred to, in part, by Mr. Perle.

The first are tests whose purpose it is to ensure reliability and confidence in our stockpile. Unfortunately, we have not been able to talk too much at the unclassified level about the problems that have occurred in the stockpile that have required nuclear tests for their identification or for fixing them.

I would like to submit for the record a report prepared by Dr. Jack Rosengren for the Department of Energy under the title "Some Little-Publicized Difficulties With a Nuclear Freeze." [See p. 52.]

In this report Dr. Rosengren identifies six specific historical cases where nuclear testing was critical to restoring the credibility of our deterrent. One specific case cited is that at one time 75 percent of a particular type of warhead deployed aboard our Polaris submarines were not operable at all. Stockpile examination determined the problem. A nuclear test was required to fix it.

In the interim, we knew that 75 percent of those warheads as deployed would not give us not a slightly diminished yield, it would give zero yield. That is a dramatic example, but only one of a series of problems that have occurred in the U.S. stockpile and luckily we can at an unclassified level talk about those half dozen cases.

I recommend that report to all of you as a record of the kind of problems that can occur in the stockpile and why confidence and reliability testing is necessary.

Senator WARNER. What is the origin and date of that report?

Dr. BARKER. The report was published in October 1983. The work was done, I believe, over the several years previous to that. The work was supported by the Department of Energy.

Senator WARNER. Has there been a subsequent incident?

Dr. BARKER. There have been subsequent problems which cannot be discussed at the unclassified level. Unfortunately, we are still not perfect.

We have very, very bright people at our nuclear weapons laboratories working as hard as they can to make our deterrent last for as long as it needs to, but they are not perfect, they do make mistakes and these are examples of the kinds of problems that can occur.

The second category of nuclear tests has to do with nuclear weapons effects tests. Mr. Perle has pointed out that we depend on nuclear tests to verify that our nuclear command and control systems, our intelligence-gathering systems, our communications satellites, as well as a vast variety of nuclear hardware can survive adequately in specified nuclear environments.

Those nuclear weapons effects tests, while small in number each year, are critical to our confidence that our deterrent is a viable one.

The third category of weapons development tests ranges all the way from developing the enhanced safety and security concepts Mr. Perle spoke of to actual tests devoted to the modernization of specific weapon systems.

I think it is interesting to observe that so-called modernization is really in response to Soviet improvements that have diminished the effectiveness of our deterrent. Soviet advances in both nuclear and conventional capabilities have threatened the survivability of existing delivery systems and have caused us to go to different more survivable delivery systems. These new systems impose a very different environment on the warhead which has caused us to ask the nuclear weapon laboratories to develop a new warhead for each new system.

One can go down the long list, Trident, B–1, all cases where the survivability of the original delivery systems caused us to deploy a new and more survivable system which in turn required new warheads to make them effective.

In this category of weapon development are also tests which we undertake not because the United States might necessarily be intending to deploy such systems, but because we need to understand the threats that the Soviets might pose to us.

It is very important to understand that nuclear weapon development is not a linear process. By that I mean every state that undertakes nuclear weapon development does not necessarily start out with the same design, and 20 tests later they are not at exactly the same point.

Designs branch out, and it is quite possible and indeed probable that the Soviet Union has in its inventory or has developed a capability to develop weapons which have not yet been explored thoroughly by the United States.

We need to continue to probe and understand how nuclear energy may be applied for military purposes so that we can better understand the potential Soviet threat.

The last category of nuclear tests is what the laboratories refer to as physics tests. It sounds rather esoteric. Those categories of tests are devoted to understanding the fundamental physical processes that go on inside a nuclear weapon.

The reason why we continue to make mistakes, why we continue to conduct tests and be surprised at their poor performance is because we have not yet developed the ability to understand the fundamental physics and incorporate that into our calculational capability.

Should the time ever come when we are asked to maintain a deterrent without nuclear tests, one might certainly be in a better posture to do so at some future date if an understanding develops from these physics tests.

I am not going to comment too much on the other technical aspect which is verification. Ambassador Adelman has already made the point that we believe we have found a mechanism to verify effectively the Threshold Test Ban Treaty and we have invited the Soviets to explore that possibility with us. We still look forward to that.

I personally believe that if the Soviets saw the Congress of the United States supporting the President very explicitly, that a TTBT cannot be ratified until verification improvement is achieved, we might see the Soviets being more forthcoming in meeting with us to achieve that objective.

With respect to the Comprehensive Test Ban Treaty, it is not now effectively verifiable, but the United States is conducting and has conducted for many years a very extensive and very expensive research program. That effort continues today, and is being funded both in the Department of Energy and the Department of Defense.

One example of it is an array that was dedicated in Norway almost 1 year ago, an example of the U.S. commitment to the research to improve the potential for verification of a comprehensive test ban.

Should the other requirements that the President has established occur, we would hope to have the verification capability to implement it. That, in our view, is quite far in the future.

I would like to conclude my comments there.

[The prepared statement of Dr. Barker follows:]

PREPARED STATEMENT OF DR. ROBERT B. BARKER, DEPUTY ASSISTANT DIRECTOR, U.S. ARMS CONTROL AND DISARMAMENT AGENCY

Good afternoon, I am happy to appear before this Committee for the purpose of providing an overview of the technical foundations for the Administration's views on nuclear test limitation treaties.

Careful study led us, over four years ago, to conclude that the Threshold Test Ban Treaty, in its current form, is not effectively verifiable; ratification of this treaty before verification improvements can be negotiated with the Soviet Union is not in the national security interest of the United States. The President has stated to Soviet General Secretary Gorbachev that he would be prepared to move forward on ratification of both the Threshold Test Ban Treaty and the Peaceful Nuclear Explosions Treaty as soon as agreement is reached on the use of an effective verification system. He has described to Secretary General Gorbachev a technical system, using a technique known as CORRTEX, which we believe will determine yield with an acceptable level of uncertainty.

Thorough evaluation has led the Administration to reaffirm that a comprehensive test ban remains a long-term objective of the United States; an objective which we will seek to pursue within the context of broad, deep and verifiable arms reductions,

substantially improved verification capabilities, a greater balance in conventional forces and at a time when a nuclear deterrent is no longer as essential an element as currently for international security and stability. There is much to be accomplished with respect to each of these objectives; it is not yet time to undertake negotiation of a Comprehensive Test Ban Treaty.

In a recent letter to Senator Dole, the President stated: "Any limitations on nuclear testing must be compatible with our security interests and must be effectively verifiable. Because of the continuing threat that we face now and for the foreseeable future, the security of the United States, its friends and its Allies must rely upon a credible and effective nuclear deterrent. A limited level of testing assures that our weapons are safe, effective, reliable and survivable and assures our capability to respond to the continued Soviet nuclear arms buildup. Such testing, which is conducted underground, is permitted under the existing agreements on nuclear test limitations, all of which the United States fully complies with—the TTBT, the PNET, and the Limited Test Ban Treaty (LTBT)."

NUCLEAR TESTING

The nuclear tests of the United States fall into four general categories: stockpile reliability/confidence tests; weapons effects tests; development tests; and tests designed to further understanding of the fundamental physical processes which occur in a nuclear explosion. Each category contributes to assuring that our deterrent is safe, effective, reliable, and survivable.

Stockpile reliability/confidence tests

Each year a small number of tests are directly conducted for stockpile reliability/confidence reasons. These tests can confirm that a recently produced nuclear weapon will perform properly or determine whether an older weapon is still performing as expected.

The use of the word "reliability", in conjunction with the need for nuclear testing, has confused many people. In every day usage, reliability is associated with a statement about probability—such as 99 out of 100 weapons will operate properly. Thus, apparently, many people assume that a concern about nuclear weapon reliability is a concern that today's possible reliability of 99 percent may degrade to 95 percent or 90 percent sometime in the future. This is not what concern for nuclear weapon reliability is about! What we must be concerned about is a fault in the design which dramatically reduces the expected yield or makes a nuclear weapon unsafe. Such faults could be accidentally built into a weapon during the production process or could be a result of chemical changes that occur as weapons grow old.

Such problems are not imaginary nightmares; the actual cases are all too real. While much still remains classified about problems with the U.S. nuclear stockpile, a great deal is revealed in a 1983 paper produced for the Department of Energy, authored by Jack W. Rosengren, and entitled "Some Little-Publicized Difficulties with a Nuclear Freeze." The paper discusses a half-dozen significant stockpile problems which required nuclear testing for their identification and/or fixing. This paper revealed that at one time 75 percent of one type of warhead designed for our Polaris submarines would have produced zero yield—no yield—if detonated. This is the kind of catastrophy that is the basis for our concern about nuclear weapon reliability, and, therefore, the reliability of our deterrent.

At the current time, a representative warhead, one of each new type produced, is tested to make sure that weapons from the production line will meet their design requirements. Every kind of military material, from boots to ammunition to tanks, planes, and submarines must be similarly "proof-tested", to ensure that the government is getting what it paid for—only in the case of nuclear weapons do some suggest such testing is unnecessary. While these critics of nuclear testing may believe that the computer calculations of nuclear weapon scientists are sufficient for a reliable nuclear deterrent, the Directors of the nation's nuclear weapon design laboratories are firmly on record stating that they cannot—in the absence of testing—retain confidence in the performance of weapons that their laboratories have designed.

In addition to tests of newly produced weapons, the category of stockpile reliability tests also includes the rare tests whose purpose it is to confirm that an older weapon from the U.S. inventory will still perform its function or to confirm a "fix" for a serious stockpile problem. Representative samples of older nuclear weapons are disassembled on a routine basis. Those parts of a weapon which can be fully tested in the laboratory—such as the electronic components—are so tested. The components which would produce nuclear yield are carefully examined by scientists and engineers from the nuclear weapons laboratory which was responsible for the

initial design. Nuclear weapons are not immune from corrosion and decay. These scientists and engineers are asked to evaluate whether the changes wrought by time will adversely affect performance. Routinely their answer is that performance will not be compromised by the changes that have occurred.

But should changes be observed from which it is concluded that performance may be adversely affected, then a nuclear test will be devoted to determining the true situation. If there is a problem, a solution will be designed, tested in a nuclear test, and the entire inventory of that weapon will be recalled to install the design change.

What is unique about this process of stockpile evaluation is not that a test may be required—all military materiel is routinely tested to ensure that age has not unacceptably degraded its performance. What is unique is that testing for the effects of age is so rare. A nuclear weapon destroys itself in a test and each weapon and test are expensive items. Therefore, rather than conduct routine tests of the aging nuclear weapon, we depend upon the judgment of a very few nuclear weapon scientists and engineers to tell us whether everything is in order. Why should we trust the judgment of these people? Because, these same scientists and engineers are involved in the ongoing nuclear weapon design and testing program and are constantly having their judgments about design validated repeatedly by the results of underground nuclear tests.

Thus we see that while we categorize only a very few nuclear tests as stockpile confidence or reliability tests, in reality every nuclear test is a reliability test—because every test contributes to the competence of those upon whom we ultimately depend for assurance that our deterrent is reliable.

Weapons effects tests

The second category of nuclear tests is weapons effects tests. Again this is a small number of tests in any given year but it is these tests which establish another critical aspect of a deterrent in which we can have confidence. For our deterrent to be real we must believe, and so must the Soviet Union, that we will achieve sufficient warning of an attack to maximize the survivability of our deterrent and to ensure a response unacceptable to the Soviet Union. This requires that we design our space-based advanced warning systems and our space-based communication systems to be sufficiently hardened against the effects of nuclear detonations so that they cannot be too easily disabled. We also protect our military equipment against nuclear radiations and electromagnetic impulse—again so that the Soviet Union cannot calculate that our forces would be easily destroyed in a nuclear attack.

We convince ourselves that we have successfully achieved our hardness goals for our warning, communication, and all other relevant military materiel by exposing samples of these equipments to nuclear radiations in specially designed weapons "effects" tests managed by the Department of Defense's Defense Nuclear Agency. While small in number these tests are vital to ensuring the effectiveness of the U.S. deterrent.

Development tests

Development tests comprise a major part of the nuclear tests conducted by the United States each year. Some of these tests contribute to the engineering of a specific new nuclear weapon for a specific new weapon system; other tests investigate concepts which might have utility in some future U.S. weapon system or which might be employed by the Soviet Union and, therefore, need to be protected against. Typical concepts under investigation include improved nuclear weapon safety and security features as well as concepts important to the evaluation of the Strategic Defense Initiative, such as the x-ray laser.

Modernization of U.S. nuclear weapons delivery systems has been an ongoing process. Weapons systems based on newer technology replace those that have lost effectiveness because of obsolescence; for example, air-launched cruise missile carriers and B–1 bombers are to replace penetrating B–52s. Weapons systems whose survivability may be threatened are replaced with less vulnerable systems; thus the Trident missile system is replacing the Polaris and Poseidon systems.

In every case to date, the replacement system has required a nuclear weapon different from the weapon in the system that was replaced. In some cases, physical dimensions alone preclude use of the older weapon. In other cases, existing warheads cannot survive the heat, acceleration, vibration and other environmental extremes that a new nuclear weapon will meet in the stockpile or during delivery. Even the yield requirement of the new system may be different from that of the system it replaces. As J. Carson Mark, retired head of the Theoretical Division of Los Alamos, has noted in the *Bulletin of the Atomic Scientists:* "The nuclear explo-

sive and its carrier constitute a "weapon system" of which neither part is of much use without the other * * * The weapon, tailored for * * * [its] particular delivery mode, cannot easily be used in any other way."

The Navy designed its C-4 missile to have a longer flight range, thereby permitting the Poseidon and Trident submarines to operate in larger ocean areas. No existing Navy reentry body could survive the harsh reentry environments associated with the greater missile range: a new reentry body with a new warhead made the C-4 system possible. The B-1 bomber will replace the B-52 in its role as a penetrating bomber. For the new bomber to fulfill its mission of deterrence, it must credibly be able to penetrate Soviet air defense, deliver its weapons and escape. Accordingly, bombs delivered by the B-1 must be able to withstand release at greater speed, survive a more stressing ground impact, and delay detonation while the aircraft flies out of range of the bomb's explosion. The criteria are very different from those for bombs designed for delivery by the B-52. The weapons labs have developed new nuclear designs to enable the B-1 to fulfill its mission.

In the area of tactical nuclear weapons, new development work has established the survivability of nuclear weapons in long-range artillery. The original nuclear artillery shells were designed to withstand the acceleration associated with the range of the 8-inch and 155-mm howitzers of the 1960s. In the following decades, U.S. and Soviet artillery doubled in range. Without new nuclear shells, capable of withstanding the acceleration associated with the longer ranges, U.S. nuclear artillery would be "outranged" and therefore vulnerable to destruction by conventional weapon fire.

While concern for survivability is the primary motivation for modernizing nuclear weapons systems, there are other important reasons for doing so. The military effectiveness of established systems has declined as the hardness of intended targets has increased. To reestablish past destructive capability requires new nuclear weapons systems. Another motivation for modernization comes directly from developments in the area of nuclear weapons design. In the last decade nuclear weapons laboratories have developed the technology to increase dramatically the safety and security of nuclear weapons.

Improved safety and security

In the laboratories' work on nuclear weapons safety, the concern is not that of an accidental nuclear explosion. As Mark has stated: "The high explosives which have been mostly used in connection with nuclear weapons * * * can reliably withstand the jolts and impacts encountered in normal handling, even if they should be dropped from modest heights, but they might detonate on falling on to a hard surface from a plane, for example. The concern is not that a full-scale nuclear explosion would result, since that requires a thoroughly symmetric detonation of the explosive which could not be induced by impact at one point."

In fact, two aircraft accidents have caused the high explosives in nuclear weapons to detonate: in 1966 at Palomares, Spain, and in 1968 in Thule, Greenland. In both cases there was no nuclear chain reaction, but the explosions dispersed plutonium, requiring extensive cleanup operations to eliminate the hazard to health.

As a result of developments at the nuclear weapons laboratories, it is not possible to preclude accidents that disperse plutonium. There are some relatively insensitive high-explosive mixtures that can survive quite violent impacts. The laboratories are now in the process of incorporating such explosives in new weapons systems as they are modernized. Due to the number of different nuclear weapons designed in the U.S. stockpile, it will be many years before all the weapons incorporate this improved safety feature. Because the weapons with insensitive explosives are based on new designs that differ substantially from those using older explosives, nuclear testing must be conducted before the features are incoporated in the U.S. stockpile.

Security is another area where recent developments in design are leading to dramatic improvements. Again, as weapons systems are modernized, features are being included that make it impossible for unauthorized persons to make use of a nuclear weapon. These features are an intimate part of the nuclear design and require nuclear tests to ensure that only authorized use would result in the expected performance.

Technical surprise

One long-standing mission of the nuclear weapons laboratories is to understand all means by which a nuclear explosion might be of military use. In part, this represents a desire to understand all the ways in which the U.S. might employ such explosives to enhance its security. It also represents a desire to avoid surprise from the advantages others might obtain from nuclear weapons developments.

The evolution of nuclear weapons design is not a one-dimensional process; there is no unique path that a nuclear weapons state must follow from its first nuclear explosion to subsequent developments. One cannot be confident that findings by the United States match those of the Soviet Union. With the maturity of the U.S. nuclear program, new concepts are less frequent, but they do occur. Nuclear testing is critical to determining whether a new concept will work.

Verification that a concept is feasible does not imply that it will be incorporated into weapons in the U.S. stockpile—far from it. But establishment of feasibility does permit the evaluation of the threat to this country should the Soviet Union have already incorporated it into its nuclear arsenal.

Physics tests

The fourth category of nuclear testing includes those tests which are devoted to improving the basic understanding of nuclear weapon performance. Despite the lengthy history of nuclear weapons testing in the United States, weapons scientists do not fully understand some fundamental phenomena that bear on the performance of nuclear explosives. The nuclear weapons laboratories possess the country's largest computer resources and a very impressive cadre of theoretical physicists. Yet, sometimes substantial discrepancies exist between calculation and experimental results; the mathematical models are just not yet adequate to predict reality. Economic considerations alone motivate the nuclear weapons laboratories to maximize the role of calculations in order to husband the scarce and expensive resource of nuclear tests. Thus, the objective of some nuclear tests is to improve calculations by exploring fundamental phenomena that are not yet understood, and which may be the cause of the discrepancies between calculation and experiment.

A further very real consideration since 1958 has been the recognition that a comprehensive test ban may some day preclude testing, leaving the laboratories with calculation as the sole tool for meeting their obligation to maintain confidence in the U.S. nuclear weapons stockpile. We are not now at the point where we can maintain current confidence requirements with calculation alone. Even in the last few years we have been surprised at the results of nuclear tests of weapons in production and have had to modify designs as a result of such tests.

VERIFICATION

Comprehensive test ban treaty

Effective verification is also a necessary condition for a Comprehensive Test Ban Treaty (CTBT). Today it does not exist. The U.S. has spent hundreds of millions of dollars on research to establish the basis for verifiable nuclear test limitations. This Administration is continuing that search. As part of that effort we have actively supported multilateral involvement in nuclear test ban verification studies at the 40-Nation Conference on Disarmament in Geneva.

A specific example of this research effort is U.S. support for the Norwegian Regional Seismic Array (NRSA) which uses a cluster of seismometers to detect and locate the sources of seismic disturbances—even those so weak that background noise would normally obscure them. Many of the features of NRSA would be expected to be incorporated into the in-country seismic stations which would be required as part of any future CTBT verification regime. The data from this seismic array is shared with the international community. It was dedicated in 1985 in a ceremony with international participation following its development and installation with funding provided by the Department of Energy and the Department of Defense's Advanced Research Project Agency.

The geophysical characteristics of the Norwegian site are such that the array is particularly sensitive. The research effort that will be required before such stations could be meaningfully applied to CTBT verification include: evaluation of the reliability of the instruments at the NRSA site; determination that sufficiently sensitive sites for in-country location of such arrays exist within the boundaries of potential signatory countries; and much better understanding of the transmission of weak seismic signals within the boundaries of signatory countries.

While only one example, NRSA demonstrates our commitment to establish a basis for effective verification should the other conditions established by the President for Comprehensive Test Ban negotiations be achieved.

Threshold test ban treaty

Turning to the Threshold Test Ban Treaty, the President has made clear that he is prepared to move forward on ratification of both the TTBT and PNET as soon as we and the Soviets can reach agreement on the use of an effective verification

system. We have described to the Soviets a technique that we call CORRTEX (Continuous Reflectometry for Radius Versus Time Experiment), which can provide acceptable uncertainty in estimating the yield of high yield nuclear tests consistent with the 150 kt threshold. CORRTEX will measure yield without compromising other potentially sensitive information about the performance of the nuclear explosion.

CORRTEX is a hydrodynamic yield measurement technique that measures the propagation of the underground shock wave from an explosion. This technique uses a coaxial cable which is shorted out by the shock wave as it propagates from the center of the explosion. The coaxial cable is emplaced in a hole parallel to the device emplacement hole. Precise measurments are made of the length of the cable by timing the return of low energy electrical pulses sent down to, and reflected from, the cable end. When the nuclear device is detonated, a shock wave emanates through the ground, crushing and shortening the cable. The rate by which the cable length changes is recorded via measurements of the changing pulse transit times. This rate is a measure of the propagation rate of the explosive shock wave through the ground which is, in turn, a measure of the propagation rate of the explosive shock wave through the ground which is, in turn, a measure of the yield of the nuclear explosion.

CORRTEX has been shown to be accurate to within 30 percent of more direct, radio-chemical yield measurements for tests of yield greater than 50 kilotons and in the geological media of the U.S. test site. This is based on over 100 tests with the sensing cable in the device emplacement hole and four tests with cables in a satellite hole. The accuracy of the technique is believed to be relatively independent of the geological medium, provided the satellite hole measurements are made in the "strong shock" region near the nuclear device explosion. At greater separation distances, the properties of the medium become much more important factors. A satellite hole separation distance of 14 meters (46 feet) is appropriate for a test near 150 kt.

The electronic device that provides the timing signals is a battery-powered suitcase-sized unit that may be remotely controlled. All equipment for power, recording, and data reduction can be contained in a small trailer.

The President invited the Soviets to send technical experts to our Nevada Test Site to observe CORRTEX measurements with the hope that this could begin the process of agreeing to its implementation as a basis for an effectively verifiable TTBT.

The test to which we invited the Soviets has already occurred—without the presence of a Soviet technical team. We hope that the Soviets will ultimately respond positively and observe similar measurements on a future U.S. nuclear test. Congressional support for the President's proposal can only enhance the prospects for a positive Soviet response which could lead to ratification of the TTBT and PNET.

Senator WARNER. Thank you.

We will have a round of questions here of 10 minutes by each member present. I will lead off.

Secretary Perle, would you say that the continuation of test programs is critical to the following programs now under development by the United States, the small ICBM, Trident II, SRAM II, and such additional work that we may be doing?

Mr. PERLE. Yes, Mr. Chairman, I believe in every case additional testing is required.

Senator WARNER. I was speaking of the earth-penetrating warheads. It is absolutely essential to the continuation of those programs?

Mr. PERLE. Absolutely essential.

Senator WARNER. Mr. Adelman, we are going to hear later this afternoon from a panel of highly respected individuals who take a position presumably contrary to those expressed by you and others.

Given the effort of the United States over time to make an approach on the Threshold Test Ban Treaty, why do you suppose the Soviets have not been willing to come forward and join us?

Mr. ADELMAN. Because, as I say, Mr. Chairman, verification is our problem. It is not a Soviet problem. We are an open society,

they are a closed society. We do not cheat on our arms control agreements. They have an established pattern of cheating on arms control.

As we know from the nuclear accident over the weekend, their society will not inform anybody outside their borders of the most catastrophic nuclear accident in history until they absolutely have to.

Therefore, they cannot be trusted to comply with something unless we know it.

Senator WARNER. Why do you have such faith and confidence in this one system that has been proposed to solve the Threshold Test Ban Treaty?

Could they not meddle with they system?

Mr. ADELMAN. They could not meddle with the system if our people are on the ground right there to monitor the test.

Senator WARNER. It would require not only installation of the system called the CORRTEX system, but persons or representatives selected by the United States and the Soviet Union to be physically present at all times?

Mr. ADELMAN. Yes. We have invited the Soviets to come here and do exactly that with our nuclear tests.

Senator WARNER. To both the Ambassador and Mr. Perle, what would be the impact of the House passage of House Joint Resolution 3 on United States efforts to induce the Soviets to resolve our concerns over the Threshold Test Ban Treaty?

Mr. PERLE. I think that it would set back seriously the prospects for negotiating with the Soviets and improving the verification regime for the Threshold Test Ban.

House Joint Resolution 3 simply calls on the United States to ratify and verify the Threshold Test Ban without improvements in the verification arrangements.

Obviously, if the Soviets believe that supporting their position is the Congress of the United States, they would be less inclined to respond to U.S. proposals made to them.

I think it is a great shame that at precisely the moment it began to look as though they might show some interest in negotiating an improved verification regime, the House of Representatives in effect told them it was not necessary to do that.

Mr. ADELMAN. Let me add to that, Mr. Chairman, that we did have some soundings before the House action among some Soviets that they might be interested in having a visit to our test range or at least exploring on an expert level, and we have had no soundings since the House passage of House Joint Resolution 3.

Senator WARNER. Can you elaborate on where those soundings came from?

Mr. ADELMAN. No, I cannot.

Senator KENNEDY. Can we find out exactly what information was given and what our reaction was?

Senator GOLDWATER. The Senator's point is well taken. We will arrange for a classified session on the subject of testing.

The Threshold Test Ban Treaty set at 150 KT is being looked at in terms of bringing that 150 number down.

What are the implications of bringing that down and specifically on the Trident II Program?

I will ask all three to answer.

Dr. BARKER. Let me respond, if I may.

The laboratory directors have indicated that with a 150-kiloton threshold that they feel able, confidently able, to develop new weapons for the stockpile with yields approximately a factor of two higher than that threshold [deleted].

So, clearly any reduced threshold will have a dramatic impact on our ability to continue to certify the reliability of existing stockpile weapons and will clearly have an impact on the country's ability to develop new weapons for important strategic systems such as Trident II.

Senator WARNER. Mr. Adelman, will you comment on the proposals contained in the Danforth-Pell resolution to reduce the yield threshold and establishing quota limits on test programs?

Mr. ADELMAN. I think Bob Barker just did that, Mr. Chairman.

Senator WARNER. Any other comments on that, because that will be an issue on the floor. I want to make sure the record is complete.

Dr. BARKER. There are two aspects of Pell-Danforth.

One is reduced threshold to which I just commented.

The other aspect is a quota, presumably at some number lower than we are currently testing at. The current number of tests is a minimum level. Tests are expensive. Tests are complicated. We do not have the resources to conduct maybe even the number of tests that the laboratory directors would feel most comfortable with at the current time.

Any reduction in the number of tests would clearly have a very negative impact on our ability to conduct the tests for the four functions I mentioned: Stockpile reliability, weapon effects, weapon development, and physics tests.

Any reduction would damage each of those four and would clearly have a negative impact on our ability to maintain a credible deterrent.

Senator WARNER. To the extent this question can be answered in the open, what percentage of the weapons in the U.S. stockpile already contain modern safety and security features?

Dr. BARKER. I cannot be very specific, unfortunately, in unclassified testimony. I can say from a personal point of view it is unfortunately a small fraction.

There is a lot of work yet to be done. One most promising accomplishment as far as enhanced security and safety is insensitive high explosive (IHE).

While IHE can perform its function when detonated properly in nuclear weapons, it can survive any kind of imaginable accident without detonating, and thus practically precludes the dispersal of plutonium in an accident situation, I think this country should have the objective of seeing insensitive high explosives incorporated throughout the entire stockpile, but we have a very long way to go.

Mr. ADELMAN. Mr. Chairman, when I was at one of the labs, I observed that a great deal of work was being done in this area. In the 1960's we experienced some accidents where plutonium was dispersed—in Spain and one other incident.

I would hate to think that any kind of an arms control proposal was going to increase the risk that, God forbid, if an accident in a plane carrying nuclear weapons were to take place in the future, that we would not be able to ensure the safety and security of the people around.

I think this kind of research would be research wholly supported by anybody who knew about it. It makes nuclear weapons safer.

Mr. PERLE. Mr. Chairman, we live in an age of terrorism. Early in the weapons program, concern about terrorism was not nearly as much a concern as it is today. A great deal of work has been done, particularly with smaller nuclear weapons, to assure that were they to fall in the hands of terrorists, they could not be detonated by those terrorists.

This involves in some cases spectacular and innovative technology that renders a nuclear weapon unusable by anyone other than an appropriate authority. That kind of work must continue. It is vital. If anything, it is more urgent now than it was before.

This is just one of the many ways in which we have sought to make the nuclear stockpile, with which we are unhappily burdened so long as we depend on deterrence, as safe as we possibly can.

Dr. BARKER. Both the enhanced safety concept and enhanced security concept will require testing of any weapon which incorporates them. It is not a matter of just slapping these things on existing weapons. They are an intimate part of the nuclear design. They have to be tested in order to ascertain that they, themselves, have not compromised the performance of the weapon.

Senator WARNER. The present draft treaty would preclude that, in your judgment?

Dr. BARKER. The Comprehensive Test Ban would preclude it.

Senator WARNER. On the Threshold, could you lay out a road map on the assumption that we get a breakthrough and the Soviets are willing to entertain a compromise in the area of verification?

It would be my hope that this would come about from the summit process, the ongoing arms control talks, and that Congress should be aware of that as we proceed to look at these issues as they arise on the Senate floor.

What is your recommendation as to how this could be handled?

Mr. ADELMAN. Our first priority in arms control is deep reductions in nuclear weapons in a stablizing way. I do not think anything should detract from that main priority. It is impossible for me to hear an agreement or buy an argument that a comprehensive test ban or limits on testing would reduce the number of nuclear weapons by one any time sooner or have such a beneficial effect.

I think we should keep our eye on the main problem which is that there are too many nuclear weapons in the world.

The scenario that I would seek would be that the Soviets would accept our invitation to come over here, to be briefed on the CORRTEX system, and visit the Nevada test site. We would do the same in the Soviet Union. We would get our experts together on a verification protocol and understanding, whatever you would like to call it.

It would be appended to the TTBT and PNET.

Senator WARNER. In the present form?

Mr. ADELMAN. This would be in addition to those.

Senator WARNER. We talk about amendments and modifications.

Mr. ADELMAN. This would be in addition to.

Senator WARNER. Design the treaty as a protocol covering ratification?

Mr. ADELMAN. That is right. I do not think it would be a cumbersome process. I do not think it would involve long negotiations. I do not think it would be very onerous to the Soviet Union.

What we are talking about is a device that is not so intrusive at all. If they are not going to buy this kind of verification, it is hard to understand what kind of onsite inspection they would possibly have in mind in the other kinds of arms control talks that we are engaged in right now.

We had to have some agreement in the Peaceful Nuclear Explosions Treaty with onsite inspection which has allowed in certain circumstances a series of tests whose aggregate yield would total over 150 kilotons. Since the Peaceful Nuclear Explosions Treaty was signed in the mid-1970's there has not been such as that series, so it would not have come into effect.

Senator WARNER. We have been abiding by that treaty for how long?

Mr. ADELMAN. For 10 years.

Senator WARNER. The 150-kiloton threshold?

Mr. ADELMAN. The Threshold Test Ban Treaty was 1974 and the Peaceful Nuclear Explosives Treaty was 1976.

Senator WARNER. We have been abiding by it?

Mr. ADELMAN. That is correct, since March 31, 1976.

Mr. Chairman, let me reiterate that we have serious concern that the Soviets do not have. We think there have been likely violations in the adherence to the TTBT.

Senator WARNER. Both the TTBT and PNET?

Mr. ADELMAN. The Threshold Test Ban Treaty.

Senator WARNER. Senator Stennis.

Senator STENNIS. Mr. Chairman, I will pass.

Senator WARNER. Then Mr. Levin.

Senator LEVIN. First, Mr. Perle, relative to House Joint Resolution 3, I think you characterized it as being a resolution which simply calls for ratification by the Senate of the Threshold Test Ban Treaty, without any reference to a reservation on the subject of verification, that would play right in the hands of the Soviet negotiators.

I am reading House Joint Resolution 3. Paragraph 1 says:

> Resolved by the House that the President of the United States should at the earliest possible date request the advice and consent of the Senate to ratification with a report containing any plan the President may have to negotiate supplemental verification, or if the President believes it necessary, any understanding or reservation on the subject of verification which should be attached to the Threshold Test Ban Peaceful Nuclear Explosion Treaty.

Do you have a different version of House Joint Resolution 3 than I have?

Mr. PERLE. I am looking at the version now.

Senator LEVIN. I wonder if there are two different versions here?

Mr. PERLE. What escapes me in the logic of that, Senator, is that it seems to countenance the difficulties we are in fact having with verification.

Senator LEVIN. I am not talking logic. I am talking about what it says. You said it makes no reference to adding an understanding or reservation on the subject of verification.

I am reading those precise words that say that if the President believes it is necessary, that he could indeed attach a reservation or an understanding on the very subject of verification.

Mr. PERLE. I find it difficult to imagine a reservation that would not vitiate the act of ratification. That language strikes me as mumbo jumbo.

Senator LEVIN. You said that language was not there. You mischaracterized House Joint Resolution 3. That is what I am asking about. You do not seem to know what is in House Joint Resolution 3.

Putting aside whether you support it or whether it is inconsistent, you said the language was not there. Is it there?

Mr. PERLE. I did not say it is not there.

Senator LEVIN. You did. You said there was no reference to a reservation or understanding on the subject of verification.

Mr. PERLE. I think what I said was that it urged the ratification of the Threshold Test Ban Treaty without improvements in the verification regime.

Senator LEVIN. Where does it say that? It says "with a report containing any plans the President may have to negotiate supplemental verification procedures."

Mr. PERLE. "Supplemental presumably means" "subsequent to ratification."

Senator LEVIN. Or if the President believes it necessary, any understanding or reservation on the subject of reservation which would be attached to the treaty. It says precisely what you say it did not say.

Mr. PERLE. As I said, it seems to me that an understanding to the effect that the treaty is not verifiable would vitiate the logic of ratification.

Senator LEVIN. You cannot say that it says something or is silent on something when indeed it is very precise on it.

Mr. PERLE. Let me acknowledge that I overlooked the glaring inconsistency in that part of the proposal.

Senator LEVIN. I think you ought to simply acknowledge that you were not aware of something which was there. That is a much more forthcoming thing to do rather than to try to argue it was there and indeed I was wrong, but it is inconsistent.

Mr. PERLE. I had overlooked it.

Senator LEVIN. Now, Secretary Perle has said that he would be opposed to a comprehensive test ban even if it were verifiable.

Mr. Adelman, do you agree with that?

Mr. ADELMAN. Under present circumstances, I do.

Senator LEVIN. The administration's position, I take it, is that you are opposed to a comprehensive test ban, you are opposed to opening negotiations on a test ban treaty at this point even if you were satisfied that it was verifiable?

Mr. ADELMAN. At this point, that is correct.

Senator LEVIN. On the question of verification, I want to ask our witnesses relative to the CIA changes in estimating procedures for assessing Soviet violations of the Threshold Test Ban Treaty.

As I understand it, according to the New York Times article and some other sources, the CIA has changed the way it measures Soviet nuclear testing.

Is that correct?

Mr. ADELMAN. [Deleted.] That means that you have to have the ability to tell when you get some measurement how accurate that measurement is, not the procedures, but the bias on that.

Senator LEVIN. Have they changed the way they estimate?

Mr. ADELMAN. [Deleted.]

Senator LEVIN. The previous estimates, as a result, were too [deleted] by a factor of perhaps [deleted] percent?

Mr. ADELMAN. [Deleted.] That does not change at all the estimate of the likelihood of the Soviets violating the Threshold Test Ban Treaty.

Senator LEVIN. I will get to that in a minute.

Mr. ADELMAN. In all our compliance reports we took that into account.

Senator LEVIN. The President, as I understand it, has signed a directive [deleted].

Is that true?

Mr. ADELMAN. [Deleted.]

Senator LEVIN. Is that report finished yet?

Mr. ADELMAN. [Deleted.]

Senator LEVIN. You just said it does not affect our conclusion.

Mr. ADELMAN. That is right. [Deleted.]

Senator LEVIN. Therefore, you know the conclusion will be that indeed our past charges will not be affected by this new directive?

Mr. ADELMAN. We wrote the compliance report in order to take care of both contingencies.

Mr. PERLE. There are two points that need to be made. [Deleted.]

Senator LEVIN. Call it method. It is simpler.

Mr. PERLE. [Deleted.]

Senator LEVIN. About [deleted] do you agree with that?

Mr. PERLE. [Deleted.]

Senator LEVIN. Did you agree with that conclusion, Mr. Perle?

Mr. PERLE. I believe that estimating yield requires more than simply a seismic answer.

Senator LEVIN. The short answer to my question is that you disagree with that conclusion?

Mr. PERLE. I disagree with the view that one can achieve high confidence in estimating yield solely on the basis of seismic signals. [Deleted.] The uncertainty remains about a factor of two which is a very considerable uncertainty.

Senator LEVIN. Is the short answer to my question that you disagree with the conclusion of that panel you referred to?

Mr. PERLE. I do not mean to be difficult. It depends on how the conclusion is understood. If it is understood to mean——

Senator LEVIN. How do you understand it? Do you agree with the conclusion as you understand it?

Mr. PERLE. I am prepared to accept it as seismology goes [deleted].

Senator LEVIN. Do you agree with the conclusion we ought to recalculate Soviet violations based on those reports?

Mr. PERLE. No. My view, Senator, is that a variety of intelligence sources ought to go into the determination of yield of which a seismic reading is only one device. Other devices, in my judgment, have been given insufficient weight in the estimation of Soviet yield.

But even under the method of calculation to which you refer, there are a number of Soviet tests, the central value of which exceeds the threshold.

Senator LEVIN. So that we are clear on the record, you have opposed a conclusion that we ought to utilize that method of calculation?

Mr. PERLE. That method alone?

Senator LEVIN. That method alone.

Mr. PERLE. I have argued for combining all the sources in making these judgments.

Senator LEVIN. As I understand it, despite your opposition, [deleted].

Mr. PERLE. [Deleted.]

Senator LEVIN. The President has ordered a reassessment of our conclusion [deleted].

Mr. PERLE. [Deleted.]

Senator LEVIN. And that report is not finished yet, but your conclusion that there were probably violations of the Threshold Treaty nonetheless will stand because you factored into that the possibility that there could be as much as a [deleted] in the calculation?

Mr. ADELMAN. [Deleted.]

Dr. BARKER. Could I offer a comment that may clarify things?

At the time when the President's compliance report was prepared, that was issued on December 23, 1985, all of the technical information that went into the seismic panel's judgment was available for consideration by the administration. Now new information has been generated, to my knowledge, which would affect the conclusion of the President's last compliance report.

Senator LEVIN. Thank you.

Mr. Adelman, have we tested the warheads for the Trident II and the Midgetman missile?

Mr. ADELMAN. I do not know.

Dr. BARKER. I can answer that question.

The Trident II testing is not complete. The small ICBM Midgetman warhead, while it is generally assumed that the MX warhead will be the baseline design for the small ICBM, that decision has not yet been made.

The small ICBM does expose the warhead to environments that are different from that to which warhead would be exposed in a silo. The small ICBM warhead will be in a missile that will be traveling across the desert. It may see extremes of temperature which are different from what a warhead in the silo will see.

Because this missile will also be mobile, it may be vulnerable to threats that that missile in the silo will not be exposed to. Before the warhead decision is finally made on the small ICBM, those factors will have to be considered.

Does the different environment and does the threat of a potential terrorist cause you to want to include in that design features that are not in the MX warhead? If that decision is made, a nuclear test will clearly be required.

Senator LEVIN. My time is up.

Senator QUAYLE. This is the second day of hearings we have had on this issue. We first addressed this issue in our hearing on the Department of Energy National Security Programs. One of the things that I think was lacking in the first hearing and also in this one is a discussion for the nuclear weapons effects testing, particularly against our satellites.

Dr. Barker, you mentioned it in passing.

Mr. Secretary, I do not think you touched on that.

From my point of view, this is really a very important aspect of all the testing, not just for nuclear deterrence, but also conventional. If, in fact, we get into a conventional conflict, we must have our satellites which we are far more dependent upon for C^3I than the Soviet Union who can rely more on land-based communications.

To me, weapons effect testing to increase satellite survivability is a high priority.

Mr. ADELMAN. You are right. Let me just add that something like one-fourth to one-third of the country's test budget on nuclear testing goes to the weapons' effects testing and that includes satellites that warn of a nuclear or conventional attack, and to make sure that those satellites are survivable. That is an important function.

Senator QUAYLE. Secretary Perle, do you want to add anything?

If it is an important function, I am curious why we are not discussing this more.

Mr. PERLE. I agree entirely. I did, in fact, make reference to it in my opening remarks.

Senator QUAYLE. I missed it.

Mr. PERLE. I think the reason why it is not discussed much is that the discussion of this issue has been dominated by the proponents of the Comprehensive Test Ban and they never mentioned it.

If you listen to the proponents of the Comprehensive Test Ban, its principal attraction is that it will halt the development of new nuclear warheads and that it will increase uncertainty regarding the workability of existing nuclear warheads, both of which results they consider to be desirable and both of which we consider to be undesirable. They are undesirable because uncertainty would include uncertainty about the safety and reliability and effectiveness of the weapons, and undesirable because it would prevent us from conducting precisely the kind of tests we have in mind now and that is making sure that our nuclear and nonnuclear weapons and systems of communication are as invulerable to nuclear effects as we can possibly make them.

So, we need to conduct effects testing precisely in order to be sure that our nuclear and conventional weapons systems, communications systems, and the like are not rendered ineffective by a nuclear burst over a long distance, or what have you.

Senator QUAYLE. Dr. Barker, do you want to add anything to that?

Dr. BARKER. I think they have said it very well. I think we should have done a better job of explaining to people the real importance of that part of the nuclear test program.

I hope we will do a better job in the future in making it clear to people.

Senator QUAYLE. I think it is an important aspect. As I said, though it has been mentioned in the past, it has not been emphasized enough. Even those proponents that have the philosophy of mutual assured destruction, they have to have warning. That is very critical.

Some of the critics say we should not have this reliability which I point out is necessary. We would certainly need survivability of satellites. If we do not have the weapon effects testing, I do not know how we can be more certain about that. It is a very critical component of the whole program.

Mr. ADELMAN. That is a very good point.

Let me say that arms control often is given to sloganeering and bumper-sticker kind of proposals. I think that it is peculiar to me to hear those who call for a safer world and safer deployment of nuclear weapons on the United States and Soviet sides, still want a comprehensive test ban.

A comprehensive test ban would freeze today's technology and freeze today's nuclear arsenals. It would not allow the kind of development of nuclear weapons in the future that I believe are more stabilizing and safer.

Senator QUAYLE. Let me focus on Ambassador Adelman, if I can, on the Threshold Test Ban Treaty and Peaceful Nuclear Explosives Treaty.

How many peaceful nuclear explosions do you think the Soviets have had?

Mr. ADELMAN. The whole concept troubles me, to tell you the truth, because——

Senator QUAYLE. It troubles me, too.

Mr. ADELMAN. Good.

Senator QUAYLE. That is why I ask the question about the likely definitional purposes of the Peaceful Nuclear Explosive Treaty.

Mr. PERLE. Not counting the one on Friday.

Senator QUAYLE. Not the one on Friday.

Mr. ADELMAN. The idea was to allow some kind of cap that, as I understand it, the Soviets wanted to have a capability of using nuclear explosions for dams and riverways. The whole idea in the Soviet Union that you can have a way of telling the difference between a peaceful nuclear explosion and a military nuclear explosion or test of an actual weapon system just on their word is troublesome.

Senator QUAYLE. Why don't we, as far as a policy, basically forget about the Peaceful Nuclear Explosives Treaty and just focus on the Threshold Test Ban Treaty?

I think you get into definitional problems. I think India claims their weapons tests are peaceful.

Don't you think you are getting into problems with other countries around the world on really a definitional characterization?

We might want to drop the 1976 treaty and just focus on the Threshold Test Ban Treaty and what that threshold ought to be.

Mr. ADELMAN. I think that this is a legacy of the past. Now that we have the distinction that was built in the mid-1970's to just pay attention to the Threshold Test Ban Treaty and not to anything with the PNET would mean that the Soviets could, therefore, test above 150 kilotons and just tell us it was a peaceful nuclear explosion because they were unregulated.

Senator QUAYLE. Say just everything is a nuclear weapons test?

Mr. ADELMAN. Then you would have to go back and say that every kind of nuclear explosion would be subject to the 150-kiloton limitation in the Threshold Test Ban Treaty.

Senator QUAYLE. Does that not make more sense?

Mr. ADELMAN. If we were starting over, it would make more sense to me, but we are not starting over.

Mr. PERLE. The nuclear weapons industry has an unparalleled record for wrong predictions. One of the predictions in the seventies was that we would make extensive use of peaceful nuclear explosions for excavations and the like.

Can you imagine getting an environmental impact statement to build canals and tunnels?

Even the Soviets have not made much use of peaceful nuclear explosions. It is now clear we are unlikely to do so and one could, I should think, simply ban outright peaceful nuclear explosions in connection with any improvement, in any further negotiations that would effect weapons testing.

Dr. BARKER. I want to make a point that a peaceful nuclear explosion is by definition an explosion that does not occur at a nuclear weapons test site.

A peaceful nuclear explosion is more often characterized by its apparent purpose rather than where it was detonated. We have no way of knowing; every single one of these so-called peaceful nuclear explosions may very well have been a weapons test.

Then the energy may have been used for some purpose associated with civil engineering. The Soviets have used nuclear explosions for seismic sounding, for creating large cavities for storage of petroleum products, and so forth.

They continue to do this to this day. But the thing that explodes, we have no way of knowing that it is not a weapon. What the Peaceful Nuclear Explosion Treaty did in that timeframe—there was anticipation that we and the Soviets would have peaceful nuclear explosions—was to provide a way to measure yield in those devices.

PNET as written is much more verifiable than the Threshold Ban Treaty.

Senator QUAYLE. If we had it all under the nuclear testing; then you would not have——

Dr. BARKER. Clearly a simpler solution.

Mr. PERLE. If one thinks in terms of a Comprehensive Test Ban—even if it were in every other respect absolutely verifiable, and it is not—permitting peaceful nuclear explosions together with a comprehensive test ban would create such a monstrous loophole that the risks would be very great indeed that the Soviets would test weapons and declare them to have a peaceful application.

Senator QUAYLE. It is a huge loophole.

Mr. ADELMAN. To be fair, those who want a comprehensive test ban want a comprehensive test ban and not any loophole for peaceful nuclear explosions.

Senator QUAYLE. Is 150 kiloton limit sufficient?

Mr. ADELMAN. It has been judged sufficient over these 11 or 12 years.

Senator QUAYLE. Mr. Barker?

Dr. BARKER. Lab directors for the last 10 years have been asked that question. They have continued to assure the government that they can attest to the reliability of all weapons in the stockpile and can meet every military requirement of which they are aware.

The first of those two categories was in the stockpile which I believe will hold true for the indefinite future. As far as being able to meet future requirements, that very much depends on what weapon requirements are generated by the Department of Defense.

It certainly is possible to conceive of a day when a military requirement might be generated for a warhead for which the laboratory directors would have to say we cannot develop that with a test below 150 kilotons.

Mr. ADELMAN. We know of no such instance right now.

Senator WARNER. I want to bring to the attention of the Senators we have scheduled a special briefing for the Senators at 6 p.m. on the tragedy in the Soviet Union. We have another panel waiting.

So, bearing that in mind, would you like to propound some questions, Mr. Exon?

Senator EXON. Thank you very much, Mr. Chairman.

I wish you had been here earlier to say that.

Mr. ADELMAN. There has been no filibuster.

Senator EXON. Gentlemen, can you describe the nuclear balance between the two superpowers and our allies if we tomorrow quit testing or reached a universally acceptable and verifiable Test Ban Treaty with the Soviet Union?

Mr. PERLE. Senator, in the immediate aftermath of such a cutoff there would be no change. We would each have the inventory that we have at present.

Over time there could be changes, some of which we might be aware of, some of which we might not be aware of.

Senator EXON. What would the balance be tomorrow if we stopped testing?

Do you think our deterrent would in fact deter the Soviets from any strikes?

Mr. PERLE. Yes; I think today we can deter the Soviets from a strike and in the immediate aftermath of a test ban.

Senator EXON. What is the following point you were about to make?

Mr. PERLE. Over time there would be changes. I think it is impossible to anticipate those changes, but there are some factors that bear on them.

One factor is that we would have to terminate some of our safety programs. We would have to terminate some of our new weapon design programs.

Senator EXON. So would the Soviets.

Mr. PERLE. So would the Soviets, and uncertainties would increase over time as to the effectiveness, safety and reliability of our stockpile and all of those things that concern us.

Moreover, if you believe, as I do, that we depend on nuclear weapons in part because of a demonstrated Soviet superiority with respect to conventional forces, they could tolerate greater uncertainty than we could.

Senator EXON. That is the next question. You know, you keep broadening the scope here. If I understood your answer, Mr. Perle, you indicated that if we did stop testing tomorrow and it was verifiable, that, at least for the immediate future both sides would have sufficient deterrent forces; is that right?

Mr. PERLE. I think for the immediate future, but certain things would stop that bear on the effectiveness and stability of the balance over time.

The D–5 would very likely stop, the Midgetman would very likely stop, and so on.

Senator EXON. And their improvements would stop, would they not?

Mr. PERLE. That is correct, their improvements would stop.

I would point out they are in the process now of fielding new weapons recently designed. One of the problems we face overall is the relative antiquity of the U.S. arsenal in relation to the Soviet arsenal. Ours is older, and we are now at a phase of modernization that the Soviets had already completed.

Mr. ADELMAN. If I could add two points to that, Senator.

One is that the function of nuclear weapons in the U.S. arsenal is more robust than it is in the Soviet arsenal. That is known as extended deterrence. We want to protect our friends and allies around the world, not just from nuclear attack, but also from a conventional attack.

So, we have had a policy since the end of World War II to have extended deterrence, and the nuclear weapon in the U.S. arsenal fulfills that more robust function.

The second point is that there is a basic dichotomy between the United States and Soviet experts on testing. Once we went through a testing moratorium in 1958–61. We had a situation where, by and large, many of the experts from our labs and the people in the nuclear weapon business left and our core of expertise dissipated over time.

In the Soviet Union, of course, being a totalitarian society, they can keep their experts right there. Indeed, after the Soviets ended the moratorium President Kennedy said that should teach us a lession never to enter into a moratorium like this again.

We saw that they were ready to hit the ground running where we took a good number of months, if not years, to assemble our expertise once again.

That is just a difference in our societies. We have a historical basis, and it is not a theory; it is real history.

Dr. BARKER. Could I comment on that question about strategic balance?

Senator EXON. Certainly.

Dr. BARKER. I think over maybe not too long a term there are two dangers to the course you described.

One is the fact that the threats that make some of our delivery systems less credible do not arise from Soviet nuclear forces, but can arise from Soviet conventional weapons capability. After all, the B–52——

Senator EXON. That sounds to me like more of a defense for our system than answering my question.

Dr. BARKER. Maybe I did not make myself clear. My point was not conventional forces *per se,* but rather the conventional capability such as conventional air defense capability is what made part of our nuclear deterrent; namely, the B–52, a less credible delivery capability.

For that reason, we developed the air-launched cruise missile and the B–1 bomber to modernize and maintain a deterrent we already had.

Those two developments required new nuclear weapons to make those delivery systems viable. We went from the Poseidon and Polaris submarine to the Trident because of our concern about potential Soviet antisubmarine warfare capability, not just because of any Soviet nuclear threat to those submarines, but moving to a Trident caused us to develop a missile which in turn caused us to develop a new warhead for that missile.

So, a nuclear test ban does not prevent the kind of developments which cause threats to our deterrent and which we can now respond to because we can conduct nuclear tests. We would not be able to respond to such threats in the future without nuclear tests.

One last factor is the issue of problems in the stockpile. I mentioned in my brief testimony that at one point in the past, we woke up one day and found 75 percent of our warheads at sea did not work. That is the kind of thing that scares me about the future because I cannot predict the day, the moment, and year when a similar problem may occur. If such an event occurs, I think it would clearly upset the strategic balance on the day it did happen.

Senator EXON. I do not underestimate the Soviet threat. I am fearful when we hear from these administration witnesses that there is no way that the United States is going to agree to a nuclear test ban treaty. You all just said it. You said we cannot agree to it because we are too far behind.

I want to tell you that with that kind of attitude, we are back to the situation, it seems to me, where we are not going to agree to a nuclear test ban treaty or a reduction in weapons until we are sure we are going to be ahead when we get through.

With that kind of attitude, we are never going to come to an agreement with the Soviet Union, even if they want to, and I am not sure they do. One of the questions I want to ask is that while the Soviet Union and United States continue to suspect each other and continue to build up, are there not Third World nations which are moving like a juggernaut on nuclear devices of their own? It seems to me that must be as much concern to the Soviet leadership as to us.

We could be in a place 10 or 15 years from now where, regardless of the strategic balance between the United States and the Soviet Union, we could find both of ourselves in the soup, so to speak, because we no longer have overall control.

That is something I suggest we had better think about.

Do you agree?

Mr. ADELMAN. Yes, Senator. Let me answer both parts of your question.

First, I hope that our arguments here were not just that we need nuclear testing because the Soviets are so far ahead. I think we need nuclear testing for the safety and reliability of our deterrent, for safety and reliability of attack warning satellites, and the other reasons that we have given.

I think with this committee's advice and authority on the nuclear arsenal, we can move toward a more stabilizing world in that respect.

Second, proliferation is a big concern.

Senator WARNER. We are anxious that Mr. Kennedy have an opportunity to question. Also Senator Nunn and I are trying to work out a solution to the problem that we want very much to hear from the next panel.

I will be happy to entertain what options we have.

Mr. ADELMAN. Let me say we are working on nonproliferation. It is a serious problem and we attend to it on a daily basis.

Senator EXON. Thank you, Mr. Chairman.

Senator KENNEDY. I know the hour is late but I am very interested in hearing from the second panel as well whose members have also devoted a great deal of their lives to this issue. I think this hearing would benefit from their views.

Senator WARNER. I share those views. I am anxious to receive their testimony.

It seems to me the option is as follows: On the assumption that many Senators will be attending the special briefing probably until 6:40 p.m. we could regroup here and continue this hearing at 7 p.m.

I have tried to ascertain the availability of three witnesses at 7 pm. Has that been done yet?

Senator NUNN. They are doing that now. I am asking whether it is preferable to do this this evening or try to reschedule when they are back in town?

Senator EXON. Mr. Chairman, may I suggest we ask Senator Kennedy to finish and at least we have 15 minutes.

Senator WARNER. I do not think we have wasted it.

Senator KENNEDY. I will be glad to help resolve it because I would like to have a chance to inquire of these witnesses. We have some from out of town.

I do not know whether you can come back. Are you going to be back in Washington anytime soon?

Dr. BETHE. I am afraid I am not planning to come back to Washington for many months.

Senator KENNEDY. Mr. Chairman, I will withhold my penetrating questions and I will have a chance at Mr. Adelman and Mr. Perle another time.

Senator NUNN. If we can get the Senators to stay, there is no reason we cannot go ahead with the hearing.

Senator WARNER. I am prepared to remain and continue the hearing.

Senator KENNEDY. I had previously asked for a briefing on another subject from the Central Intelligence Agency that was scheduled for 5:30 p.m.

I understand now they are briefing myself and several other Senators at 6 so I will have to leave soon. I certainly would welcome the opportunity to hear the opening statement of both witnesses.

I will withhold my questions until the second panel.

Senator LEVIN. Can questions be submitted for the record?

Senator WARNER. Yes.

[Whereupon, at 5:48 p.m., the committee proceeded in open session.]

OPEN SESSION

Senator WARNER. Senator Kennedy, I apologize for the shortage of time. It is beyond my control. We will reconvene with the second panel as quickly as we can.

Senator KENNEDY. If I can make a suggestion. If the Chair thought it was appropriate, perhaps the witnesses could respond to the opinions that were expressed by the previous panel. First, Dr. Hans Bethe, since he is an out-of-town guest, could respond to the principal arguments they presented with regard to verification, reliability, reduction in yield, strategic modernization and physical security from terrorist activity.

I think those are generally the five areas. If they would not mind discussing those particular areas, which I think are the focus of the debate, then they can file those statements and return to points they think would be of particular relevance to us. I would certainly be grateful if we could proceed this way and I think it would be very helpful for the record of this hearing.

Senator WARNER. Without objection. Would you proceed Dr. Bethe.

STATEMENT OF HANS BETHE, PROFESSOR EMERITUS, CORNELL UNIVERSITY AND NOBEL LAUREATE

COMMENTS ON TESTIMONY BY GOVERNMENT WITNESSES

Dr. BETHE. I will be glad to do exactly that. I first want to add something to the testimony of Mr. Perle. He said if we had concluded a test ban in the sixties, then our stockpile of weapons would be much less effective than it is today.

That is true, but if we had done so, then the Soviets could not have developed any submegaton thermonuclear weapons. They did not have any such weapons by the year 1961 and I know that because at that time I was the chairman of a committee analyzing the Soviet tests.

We could do that in those days because they were half strong. They had only nuclear weapons of several megatons. Now, if you have no submegaton thermonuclear weapons, that means you cannot have MIRV, you cannot have multiple, independently targetable reentry vehicles.

We have been particularly afraid of the MIRV'ed SS–18 which makes use of such submegaton thermonuclear weapons. If we had stopped at that time, then we would be much less threatened than we are today.

I said that, by the way, in 1960 in an article in Atlantic Monthly. It always is a two-way street. You must look not only at your own

weapons development, but you also have to look at the enemy's weapons development.

Of course in one respect, I agree entirely with the government witnesses: I see no alternative to the nuclear deterrent. I also agree that we need safe weapons which will not explode when they are dropped from a plane. I think we have gone quite a long way in that direction.

Let me next talk about the question of the threshold test ban. I have here two papers by the greatest expert on seismic detection of nuclear explosion, Lynn R. Sykes of the Lamont-Doherty Geological Observatory of Columbia University. I want to submit those for the record.

Senator WARNER. Without objection.

[The articles appear on p. 84.]

Dr. BETHE. In the first one Dr. Sykes shows that you can distinguish explosions from earthquakes. This was the main question which bedeviled our negotiations back in 1958 with the Soviet Union about an underground nuclear test ban. We could not distinguish reliably explosions from earthquakes.

Now Dr. Sykes and his collaborators have shown that this distinction is now completely possible and he is talking here about 500 earthquakes which happened in a period of 6 months, I believe in 1982, and some 20 or 30 nuclear explosions.

They are completely distinguishable. So, there is a very convincing curve which puts all the earthquakes on one side and all the nuclear explosions on the other side and you can tell without question that you can distinguish these two kinds of events.

The second paper is directly relevant to the threshold text ban. What Mr. Sykes has covered is that the old method of measuring the yield of nuclear weapons by the strength of the body wave is unreliable because a body wave is attenuated differently according to the medium in which the explosion is set off.

We are setting off our explosions is alluvium. The Russians do it in granite. The explosions which are set off in a hard rock give a very strong body wave. Therefore, we are overestimating the yield of the Russian explosions very significantly if we use the old method of body waves.

If, however, you use the new method of using surface waves, then they are generated independently of the medium in which they are set off and this is a reliable way to measure the yield. On that basis you find that the strongest nuclear explosion after the threshold text ban was about 150 kilotons, which is the limit that was set in the Threshold Text Ban Treaty.

So, as far as this reliable method is concerned, the Russians have not violated the threshold text ban. Nevertheless, I would recommend very much if we could have some additional method of verification. I think we have good reason for ratification, because the ratified treaty would make it possible for us to get direct access to some Russian weapons tests.

So, I would welcome if we had such a treaty, but in the meantime, it is, I think, fairly clear that the Russians have not violated the threshold text ban.

RELIABILITY OF STOCKPILE

Now, the point I wanted to talk about a little longer is the question of reliability of the stockpile and that, of course, is the crucial point. We need our present weapons to remain reliable all the time. It is true that there has been one occasion on which this reliability was very much in question which was found out by opening some of these weapons and finding out that there was very substantial corrosion.

For that you only need inspection. Now, what do you do after that if you cannot have a nuclear test? Well, there are many things to do.

The first thing is a non-nuclear study of the implosion which the explosive generates for these weapons. We had very good methods for doing that back in World War II. We have far better methods now and I believe that just by non-nuclear methods we could determine very accurately whether a given stockpile weapon is still functional or not.

The third step which you might take has not been mentioned. It is a test at zero yield, a nuclear test at zero yield. To do this you would diminish the amount of explosive material, of nuclear material, in the weapon and then you find out whether the so diminished weapon would give a certain number of generations of neutrons.

Fifty generations of neutrons are necessary to initiate an actual explosion. So, you aim for, say, 40 generations rather than 50. You can very well observe the number of generations by detectors which are put outside the tested weapons. What you do in this case is to take all existing types of stockpiled weapons that you are interested in the future, and you would test them with diminished nuclear material and see how many generations of neutrons they give.

The good thing about this is that the zero yield testing is extremely sensitive to acutal design and if the zero yield is all right, then the actual weapon has many ways of compensating and is surely all right.

Now, the next point is suppose you find that one stockpile weapon is not reliable. In that case you have to refabricate all parts of this weapon and that will include the explosives.

It is sometimes argued that we cannot rely on that because the manufacturers may slightly change almost involuntarily the composition of the explosive. Well, I think there is a simple answer to that.

Our labs are extremely competent, both in chemistry and in explosives. Let the weapons labs fabricate the explosives. They will surely be able to stick to the same specifications that they had originally. It would add some small work to the weapons labs, but certainly an industry which is a half billion dollars a year is capable of taking on this added task.

It would, incidentally, maintain the capability of our weapons labs in still another field.

Next, I would instruct the laboratories to develop robust designs of nuclear weapons which are not very sensitive to small changes in the explosives or other parts of the design. We use to have such

designs. We could instruct the labs to go back and design better weapons of the old robust designs which are less sensitive.

This may mean some sacrifice in yield at a given weight, but this is compensated by better accuracy, which we have, and it is mainly the better accuracy of our missiles that made it possible to decrease the yield of the nuclear weapons as was mentioned by Mr. Adelman.

Finally, a fall-back position. If we are concerned about the reliability of our stockpile, let us agree not on the complete test ban, but let us agree that each of the two countries will be able to have two tests a year under 5 kilotons.

Five kilotons is enough to check that existing designs still work and at the same time is not very useful to develop new weapons. Let us limit the number of such tests to two on each side.

So, these are my remarks about the reliability of the stockpile.

Now, let me make one more remark about Dr. Barker's testimony. He mentioned four categories of weapons tests. I have no quarrel with any of the four categories, but I believe he should have added a category No. 5, namely, to develop third-generation weapons.

The development of third-generation weapons, that is SDI weapons, is certainly an endeavor which will take tremendous numbers of tests.

Now, the New York Times interviewed two responsible people at Los Alamos Laboratory, one at Johns Hopkins who has been there a long time and who, I believe, is in overall charge of the weapons program there, and the other was Robert Selden or, the head of weapons design at Los Alamos.

In particular, Dr. Selden said that it will take at least 100 to 200 tests, to perfect one of these designs, and there are five different areas of SDI weapons which are under investigation.

That means to me that if we want to go into third-generation weapons, testing will be endless. We can never agree, no matter how good the verification; no matter how much it may be in our interest, we can never stop because it takes so many tests to establish one of these futuristic devices.

Thank you.

Senator WARNER. Thank you, Dr. Bethe. We appreciate very much your patience and your testimony. You have been of great assistance to the members of the committee present today and those who will be studying the record.

We now have another compounding problem; namely, 3 more minutes for members to vote.

May I ask the two remaining witnesses if 11 o'clock tomorrow morning is a possibility for the resumption of this hearing?

The Chair and members would be most grateful, at which time we will have adequate opportunity to receive your testimony and to engage in a discussion with questions.

If that is agreeable, I express appreciation of the full committee to you.

Senator NUNN. Let me say if the doctor is going to be here—I have found his testimony fascinating—if he is going to be in town, we would love to have him, too.

Senator KENNEDY. I know Dr. Bethe is going to be leaving. I have a need for yes or no answers to four or five questions.

Senator WARNER. Why don't you continue, Senator.

Would you wait until we return?

Senator KENNEDY. I will just do it now. It will take 2 minutes.

Senator WARNER. I will ask the vote be held.

Senator KENNEDY. I think you may have answered these and I would appreciate it if the other witnesses might answer tomorrow.

On the issue of reliability, must we continue testing in order to guarantee the reliability and safety of our nuclear stockpile?

Dr. BETHE. I do not believe so. There have been better experts than myself who also do not believe so.

For instance, the former director of Los Alamos, Dr. Bradbury, and the former Chief of the Theoretical Division, Dr. J. Carson Mark, have stated that repeatedly and I think it would be useful to hear from one of them sometime.

Senator KENNEDY. Second, on the issue of strategic force modernization, must we be able to continue testing to develop the Midgetman or Trident D–5?

Dr. BETHE. It seems to me that probably we could use existing devices. The D–5, of course, is a very important weapon. We must have that. The D–5 is not all that different from previous missiles. In fact, I am told that for the moment we want to keep it at the same range as the C–4 which we have tested. So, why not give it the same warhead as the C–4.

On the Midgetman I think there is a question whether we want to make it mobile or put it in silos. In my opinion, we would be just as well off to have it in silos because a single warhead weapon is not a very attractive target for Soviet missiles.

If it is in a silo, then it has the same environment as the existing MX devices and, therefore, I think we could use that. I believe one can always make trades between one or the other.

Senator KENNEDY. On the issue of survivability, do we need to be able to continue testing to improve the survivability of our satellites and other systems?

Dr. BETHE. To ensure the survivability of our statellites, the most important thing is to stop SDI because once we have SDI deployed on both sides, then the satellites will be completely sitting ducks on both sides.

Senator KENNEDY. How about irrespective of the SDI? Simply with regard to enhancing the survivability of our satellites now, do we need to continue testing?

Dr. BETHE. I do not believe so. That depends on totally different weapons which both the Soviets and we have developed. We had the homing overlay which you know very well, Senator. Namely, we use an ICBM rocket, but no nuclear warhead whatever.

We used the ICBM rocket which had no nuclear warhead, but which had instead the homing device and then unfolded a big umbrella, about the size of this room, with little weights attached to it and that was enough to kill an ICBM and would also be even more than enough to kill a satellite.

The Soviets, of course, have also satellite killers which also have no nuclear component as far as I know.

Senator KENNEDY. Finally, is it more advantageous to the Soviet Union than to the United States to have a comprehensive test ban?

Dr. BETHE. I believe it is advantageous to both of us and to the same degree. We have had 800 nuclear weapons tests. The Soviets have had 600. We have tested somewhat different devices, I am sure. But it is a very mature art in both countries and, therefore, I think it would not hurt either of our two countries, it would not be to the advantage of either country.

Dr. FRYE. May I make two points in response to the question?

Senator LEVIN. Dr. Bethe, Senator Warner agreed if you were willing to answer the rest of our questions in writing, we would put them in the record.

Are you able to do that by mail?

Dr. BETHE. I certainly can.

Dr. FRYE. I want to make a couple of comments to Dr. Bethe's very fine statement.

I think it is important not to create the expectation that a comprehensive test ban would necessarily mean an end to SDI. It would mean, in terms of the program as it is presently planned, stopping a very small part of a very large program. I think that distinction is important for a lot of reasons you can understand.

Second, in your query about satellite vulnerability and Senator Quayle's prior question, the important point to keep in mind is that we have been working on that problem for 20 years, ever since we discovered EMP and other effects.

In the early 1960's some of us conducted for the Air Force a project known as task force Foxhit which was designed specifically to reduce Minuteman vulnerability to these phenomena. That has been a constant part of our test programs for 20 years, over 500 tests.

We have learned some things. While no one can say we solved every problem that is conceivable, in fact, we have made great progress on that issue.

Senator EXON. Are we ahead of the Soviets in that area?

Dr. BETHE. I do not know.

Senator EXON. Thank you all.

[Questions submitted for the hearing record with answers supplied follow:]

QUESTIONS SUBMITTED BY SENATOR JOHN WARNER

Senator WARNER. What would be the impact of a test ban on our ability to develop new weapons (like earth-penetrating warheads) to maintain our deterrent in the face of a changing Soviet target base?

Mr. PERLE/Dr. BARKER. A comprehensive test ban would prevent us from developing new weapons like the earth-penetrating warhead in response to new or evolving Soviet threats. Such threats could result from continued Soviet efforts to improve survivability of strategic assets, missile accuracy, air defense, ABM defense, and anti-submarine warfare capabilities—activities which would not be constrained by any test ban, but which would erode the credibility and effectiveness of our deterrent.

Senator WARNER. To what extent do nuclear weapons tests that are not specifically designed to test the reliability of the existing stockpile contribute to assessment of weapon reliability?

Dr. BARKER. In a general way, all tests add to our knowledge of nuclear weapon physics, and so contribute to our ability to assess weapon reliability. The extent of this contribution will vary with the particular test, and in general is difficult to

quantify. If detailed information is needed regarding this issue, the DoE can supply it.

Senator WARNER. Will the warhead for the small ICBM require additional testing prior to deployment? What other specific modernization programs would be impacted by a ban on nuclear testing?

Dr. BARKER. I believe additional testing is planned for a warhead for the small ICBM. Specific information on tests planned for this or other systems could be obtained from the DoE.

Senator WARNER. Is computer or other simulation techniques an effective alternative to nuclear weapons effects testing?

Dr. BARKER. Calculations and simulations play a useful and important role in nuclear effects testing, but do not eliminate the need for nuclear testing.

Senator WARNER. Is computer modeling sufficient in nuclear weapons design? How many times have we identified serious problems in nuclear weapons design as a result of actual testing?

Dr. BARKER. Modeling is useful and necessary as a companion to nuclear testing, but by itself is not sufficient to develop and certify nuclear weapons designs. Regarding identification of problems by means of nuclear tests, the DoE could supply such detailed information.

Senator WARNER. Dr. Bethe, I believe that you argue that certain risks associated with a comprehensive test ban are acceptable. Is this a policy judgment on your part, or is it a judgment that you make on technical grounds?

Dr. BETHE. My judgment that risks associated with a comprehensive test ban are acceptable is made on technical grounds. Government witnesses have argued that in case of a CTB we could no longer rely on our stockpile of nuclear weapons. I believe this argument is incorrect, and I am mentioning several methods to maintain our confidence in the reliability of our stockpile.

Of course, I consider a CTB desirable. President Eisenhower and his Secretary of State John Foster Dulles considered a ban desirable partly because there was political pressure from the Soviet Union to have such a ban. At present we are under similar political pressure. In my opinion, we do not gain anything, relative to the Soviets, by further testing. But my main point was that a test ban would be acceptable from the technical point of view of affecting reliability of our stockpile.

QUESTIONS SUBMITTED BY SENATOR CARL LEVIN

Senator LEVIN. At what minimum level of nuclear explosive yield does the U.S. have high confidence that it can detect any systematic series of tests of nuclear devices with a yield above that minimum level?

Mr. PERLE/Mr. ADELMAN/Dr. BARKER. Effective verification of compliance with the provisions of any arms control agreements usually requires that a single meaningful violation must be detected. In the case of nuclear test limitations, it is generally agreed that a single test—even at low yield—in violation of a limitation can be critical to the side conducing the test if the test were designed to restore confidence in a weapon whose performance had become suspect, to proof test a new warhead, or to ensure the survivability of vital national security assets. Therefore, the impression that only a "systematic" series of nuclear tests can have military significance is wrong, and the ability to detect a "systematic" series of tests in violation of nuclear testing limitations has no relevance for the arms control process.

The question, however, correctly reflects the fact that there will always be yield thresholds below which the United States would be unable to detect a nuclear explosion. The magnitudes of these thresholds would depend not only on U.S. monitoring capabilities, but also on factors that only the Soviets control. These factors include the environment (i.e., underground, under water, in the atmosphere, and in outer space) in which a test is conducted, the location of the test, the testing procedures, and efforts to evade detection. Consequently, the magnitude of the thresholds can be relatively low in some circumstances and quite high in others. Most importantly, all tests, however small the yield, could have military significance.

Associated with each detection threshold is a higher threshold for identification of nuclear explosions. Its magnitude also depends on the factors discussed above and on analytical capabilities for processing data. Identification, which is the ability to determine whether a detected event is due to natural or man-made causes, and if man-made, nuclear or non-nuclear, is perhaps the most serious verification problem bearing on nuclear testing limitations at this time.

If the USSR conducted an underground nuclear explosion in the one-to-ten kiloton (kt) range, at an existing test site, in hard rock, and with no attempt at evasion, today, we could detect and identify such an explosion with high confidence.

Off-site, depending on the nature of the geology, the U.S. might not be able to detect even overt nuclear explosions of one-to-ten-kt and identify them unambiguously as nuclear explosions, rather than as earthquakes or chemical explosions. The Soviets could also thwart detection and identification by muffling a nuclear explosion in an underground cavity. The Soviet Union possesses vast salt deposits in which to construct hidden cavities. For example, today, we estimate that areas totaling the size of Texas have salt deposits thick enough for cavities which could decouple 10-kt explosions; deposits thick enough to decouple 1-kt shots extend over three times that area. The Soviets can also hide nuclear explosions in the seismic signals from earthquakes or claim that a nuclear test was a chemical explosion.

The Soviets would have the incentive to go to other environments outside the Soviet Union where U.S. monitoring capabilities are marginal. In such environments, e.g., outer space, or the atmosphere above remote ocean areas, attribution of a nuclear explosion, even if detected and identified, would be a problem. Proving a violation under these circumstances would be virtually impossible.

Senator LEVIN. Is it not true that continued testing by the Soviets will permit their development of smaller warheads with greater yield to weight ratios? Does this not permit the Soviets to increase the number of RVs on such weapons as the SS–18? Could the Soviets double the number of RVs on the SS–18 if they were able to produce warheads comparable to U.S. warheads?

Mr. PERLE/Mr. ADELMAN/Dr. BARKER. The Soviet Union has already demonstrated its ability to develop and deploy light-weight re-entry vehicles for its Submarine-Launched Ballistic Missiles. These could be adopted for the SS–18. [Deleted.] It would, however, be a grave mistake to assume that the Soviet Union cannot, at this time, deploy nuclear weapons which are as efficient as those deployed by the United States.

Senator LEVIN. Approximately what percentage of nuclear weapons tests are for the purpose of testing the reliability of the stockpile?

Mr. PERLE/Mr. ADELMAN/Dr. BARKER. All nuclear tests have stockpile reliability as an objective. Indeed, reliability is built into the stockpile using the results of our entire testing experience. And continued nuclear testing is an indispensable element by which the United States maintains long-term confidence in the nuclear weapon stockpile.

During development, each weapon is extensively tested in a program that typically starts at very low yields for development of the primary and progresses up to full-yield detonations or to 150kt, whichever is lower. Nuclear effects tests of a weaponized version and confidence tests of a production-line model complete the testing required for the certification of a particular weapon.

During the stockpile life of that weapon, reliability problems uncovered in the stockpile surveillance program are resolved by expert design teams who are familiar with the results of all past testing of the weapon and whose competence is maintained by participation in a continuing nuclear test program. Individual reliability problems are investigated and resolved by specific nuclear tests when designer judgment deems tests necessary. The adequacy of fixes or design modifications could require nuclear testing to verify; again, this is a judgment call by the weapon designer.

Eventually, the weapon becomes obsolescent due to the dynamic requirements for sustaining deterrence and is replaced in the inventory by a new design which is perfected through its own development test series. Such replacements also are a vital part of maintaining confidence in the reliability, effectiveness and, hence, the credibility of the nuclear stockpile.

Historically, approximately 80 percent of all nuclear tests were directly related to stockpile reliability. A few percent of all nuclear tests were conducted for the sole purpose of checking the reliability of particular weapons.

Senator LEVIN. How many tests have been conducted since 1970 to correct warhead defects of stockpiled weapons?

Mr. PERLE/Mr. ADELMAN/Dr. BARKER. Over one-third of all designs introduced into the stockpile since 1958, after what was considered adequate testing, encountered problems. Of these, 75 percent were discovered in the course of nuclear explosive testing and required additional testing to fix.

Since 1970, eight tests have been conducted to correct defects in stockpiled weapons.

Senator LEVIN. It is not true that the improvement and continued development of delivery vehicles—missiles, cruise missiles, aircraft—can continue independent of warhead testing?

Mr. PERLE/Mr. ADELMAN/Dr. BARKER. It is difficult to find a case where the improvements and continued development of delivery vehicles (e.g., ballistic missiles, cruise missiles, aircraft, artillery) which have been incorporated into the U.S. nuclear deterrent would have been possible without new nuclear warhead development and testing. New developments in delivery vehicles have meant changes in the acceleration, vibration, thermal loads, diameter, or other parameters which in most cases have totally precluded re-use of an older warhead. In some cases re-use of an older warhead might have been possible, but only if nuclear testing could have confirmed that the older device would operate acceptably in the new delivery system. Re-use of older warheads would prevent adopting the latest nuclear weapon safety and security features into the new delivery system.

Senator LEVIN. Is the safety and reliability of our warheads a current problem?

Mr. PERLE/Mr. ADELMAN/Dr. BARKER. No. It should be emphasized that our ability to respond confidently to such a question relies in large part on our nuclear testing program. Hard experience has shown that nuclear testing is required to ensure that any problem in the future does not go undetected and uncorrected.

Senator LEVIN. Cannot devices to insure safety and reliability of the stockpile such as the Permissive Action Locking (PAL) device be developed and tested without the requirement for exploding a nuclear warhead?

Mr. PERLE/Mr. ADELMAN/Dr. BARKER. "Permissive Action Link (PAL)" is a generic term for a device or system, included in a weapon system to prevent arming until a prescribed, discrete code or combination is set. The purpose of a PAL is to prevent unauthorized arming and launch of a nuclear weapon. The most effective PAL devices, which we have designed to provide the highest level of security attainable today, are an integral part of the warhead design. Nuclear explosive testing therefore is required to ensure that we can continue to meet our high safety and security standards without compromising the military effectiveness of our nuclear deterrent.

Senator LEVIN. Can we monitor compliance with a 100-kt test ban limit with confidence that any systematic attempts by the Soviets to violate the ban could be detected?

Mr. PERLE/Mr. ADELMAN/Dr. BARKER. No. As the President has stated on several occasions, the U.S. cannot today effectively verify Soviet compliance with the 150-kt limit under the Threshold Test Ban Treaty. The lower the threshold, the greater are the verification uncertainties. Effective verification of compliance requires the detection of all violations adverse to our national security interests. A standard of verification which is limited to the detection of systematic violations is unacceptable.

Senator LEVIN. The United States has significantly reduced the megatonnage in its nuclear stockpile since the 1960s. What percent of the reduction was accomplished through the retirement of excess and obsolete the warheads and what percent was eliminated as a result of reduced requirements for nuclear weapons?

Mr. PERLE/Mr. ADELMAN. Since the 1960s, the United States has reduced the total destructive power of its nuclear stockpile—measured in aggregate megatonnage—by approximately 75 percent. About 97 percent of this reduction was the result of the retirement of high-yield strategic weapons and three percent involved theater weapons. In all cases, the delivery systems of these weapons became obsolete, losing survivability, penetrability, and/or effectiveness because of Soviet improvements in offensive and defensive capability, both nuclear and non-nuclear.

It is important to realize that if we had had a test ban in the 1960s, we would still have these high-yield weapons in the stockpile. We would not have been able to develop new weapons with much lower yields and vastly improved safety and security features. If we were to agree to a test ban today we would not be able to make similar desirable improvements in the future.

We should also note from this experience that Soviet improvements in areas unaffected by a test ban, such as air defense, anti-ballistic missile defense, anti-submarine warfare, and hardening of strategic assets, could neutralize or reduce the effectiveness of our entire triad of present and programmed deterrent weapons. This would be an extremely dangerous development, doubly so if our options to respond were constrained by limitations on nuclear testing.

Senator LEVIN. If the question of verification is the reason for not submitting the TTBT to the Senate on ratification, why not submit the treaty with a reservation on ratification?

Mr. PERLE/Mr. ADELMAN. The administration has not sought the Senate's advice and consent on ratification of the TTBT because we cannot effectively verify Soviet compliance with the 150-kt limit. Since the question of verification goes to the heart

of the treaty, I fail to see the rationale for, or wisdom in, submitting for ratification a treaty which is not verifiable. Rather than ratify the current treaty with some kind of unilateral "reservation" stating that we need verification improvements—a position that the Soviets could simply continue to ignore, while continuing their likely violations of the 150-kt limit—we should seek Soviet agreement to the necessary verification improvements before ratification.

In addition to the real military benefits that could accrue to the Soviets from testing above the 150-kt limit, I am disturbed by the prospect of creating a very damaging precedent for any future arms reductions agreement whereby advocates of a "quick" treaty would argue that we should agree to reductions now and worry about effective verification of such an agreement later.

Senator LEVIN. Are the principal reasons for nuclear testing the modernization of our nuclear warheads and the testing of communications equipment and ancillary devices against nuclear effects?

Mr. PERLE/Mr. ADELMAN. The overriding reason for nuclear testing is to maintain a credible and effective nuclear deterrent upon which we depend for our security.

Effects testing enables us to ensure the survivability of our nuclear forces, communications systems and other military assets and thus the stability, credibility and effectiveness of deterrence. The search for survivability is one of the main reasons why we must conduct nuclear explosions. Further, it is only through actual testing that we can ensure that our warheads and weapons systems are safe and secure; that they are reliable and effective; that they could, if required, perform their military missions with as little collateral damage as possible.

Testing does permit necessary "modernization" of our nuclear weapons, but "modernization" must be understood in the broader sense of permitting improved safety and reliability, as well as survivability and military effectiveness. Although "effects" testing per se does not represent a large number of nuclear tests, it is vital to understanding the possible nuclear threat faced by our communications, command, control, and intelligence (C3I) systems, as well as our weapon systems themselves.

Senator LEVIN. Could the Midgetman and the Trident II missile be equipped with warheads currently in the inventory without testing and with a high probability that the weapons would explode at predictable yields with predictable effects?

Mr. PERLE/Mr. ADELMAN. Those systems could not be fitted with warheads from our existing inventory while maintaining current high levels of confidence in their safety, reliability, effectiveness, and survivability.

Senator LEVIN. Explain how a CTB would degrade the U.S. nuclear deterrence. Would not the effects of a CTB on the Soviet nuclear deterrence be qualitatively more severe than on the U.S. deterrence?

Mr. PERLE/Mr. ADELMAN. I have explained both in testimony and in the above answers why nuclear testing is required to maintain the credibility and effectiveness of our deterrent. There are additional reasons why the Soviet Union would gain unilateral military advantages under a CTB. We believe that the U.S. depends more than the Soviet Union on high technology in warhead design and, consequently, on continued testing. For example, our standards for safety almost certainly are higher than those required by the Soviets. Since the Soviets are judged to be more conservative in their designs, their nuclear weapons stockpile could be more durable than ours in a test-ban environment. At a minimum, their missile throwweight advantage would enable them to fall back on previously tested, heavier, and relatively simpler warhead designs which may involve lower safety standards and/or higher levels of collateral damage.

Moreover, given existing verification problems and the closed nature of the Soviet society, the Soviets could test at militarily significant yields with little risk of detection. Such testing would allow them to retain confidence in the reliability of their stockpile, retain the viability of their nuclear technology base, and possibly design some new weapons. The United States, of course, would faithfully observe its international commitments—in effect placing a unilateral obligation on ourselves not to test.

For purposes of discussion, however, even if it were assumed that the Soviets' confidence in their nuclear arsenal were degraded equally with ours, it is not clear at all that Western security would be advanced by such an arrangement. As our allies have been quick to point out, we must be concerned about eliminating or compromising our nuclear deterrent in the absence of some other means of dissuading the Soviets from exploiting their conventional force advantages to carry out aggression at our expense.

QUESTIONS SUBMITTED BY SENATOR EDWARD KENNEDY

Senator KENNEDY. Secretary Perle, do you anticipate a requirement for continued development, testing, and production of nuclear weapons into the twenty-first century?

If yes, how does this correspond to the President and General Abrahamson's assertions that the major elements of an SDI system would be in place by the year 2,000, a system that is supposed to render nuclear weapons impotent and obsolete?

Mr. PERLE. Nuclear weapons will remain the key element of our deterrent to Soviet aggression for the foreseeable future. During such a period, where both the U.S. and our friends and allies must rely upon nuclear weapons to ensure Western security, we will need to continue to ensure the safety, reliability, effectiveness, and survivability of those weapons—in short, the credibility of our deterrent—through a well-structured program of testing, development, and production.

Let me emphasize that my use of the terms "development" and "production" should not be taken out of context to imply that the U.S. is somehow committed to the proliferation for more—and more devastating—nuclear weapons. To the contrary, as we have pointed out during this hearing, the experience gained through nuclear testing has been vital to our ability to reduce signficantly both the numbers of U.S nuclear weapons and the aggregate megatonnage of those weapons since the 1960's without adversely affecting our overall deterrent posture. This could not have been accomplished without the development production of safer, more reliable, and more survivable weapons to replace older systems. But since the threat posed by Soviet offensive and strategic defensive efforts manifestly continues to evolve, our means—including our nuclear forest—to ensure our ability to deter aggression also must continue to evolve.

There is no conflict between the need for the foreseeable future to maintain our nuclear deterrent to Soviet aggression and the President's vision of a world in which nations could live secure in the knowledge that their national security did not rest upon the threat of nuclear retaliation but rather on the ability to defend against potential attacks. We are actively investigating technologies under the Strategic Defense Initiative research program that could one day make us less dependent on offensive nuclear weapons. Our ultimate objective is the elimination of such weapons, but that is necesarily a long-term goal. And while we see real poter tial in our SDI research, it is too early to predict the outcome of that research, or to predict whether the Soviets will cooperate in achieving a stable transition to a more secure and inherently more stable balance of defensive and offensive arms. As we have stated on many occasions, the decisions necessary to move toward a general defense against ballistic missiles will be for a future President and Congress to take.

In addition, we fully recognize the contribution that nuclear weapons make to deterring non-nuclear aggression. Therefore, we must be concerned about prematurely eliminating our nuclear deterrent—even if major elements of an SDI system were in place—in the absence of steps to diminish the threat posed by non-nuclear force imbalances.

INTERNATIONAL TREATY OBLIGATIONS

Senator KENNEDY. Mr. Adelman, in your statment you say that "A comprehensive test ban remains a long-term objective of the United States."

What does "long-term objective mean?" How long-term is long-term? Secretary of State George Shultz stated in recent Congressional testimony that, "As long as there are nuclear weapons there is a need to conduct tests." In light of this statement can we assume that the Administration has no intention of seeking a CTBT?

Mr. ADELMAN. The President has said that: "A comprehensive test ban remains a long-term objective of the United States. We believe such a ban must be viewed in the context of a time when we do not need to depend on nuclear deterrence to ensure international security and stability, and when we have achieved broad, deep, and verifiable arms reductions, subetantially improved verification capabilities, expanded confidence-building measures, and greater balance in conventional forces."

The necessary conditions for a comprehensive test ban have not yet been achieved and, therefore, the Administration does not seek a CTB at this time. How long it will take to achieve the necessary conditions is difficult to predict.

Senator KENNEDY. Do you agree that, pursuant to the Article 6 of the Non-Proliferation Treaty (NPT) and the preambles to the NPT and Peaceful Nuclear Explosions Treaty, the United States is legally obligated to seek the discontinuance of nuclear testing, and to negotiate towards that end?

Mr. ADELMAN. Preambular language is treaties, including the NPT and PNET, is hortatory, and does not create legal obligations. However, as a matter of policy, the

United States is committed to a Comprehensive Test Ban as a long-term objective and will negotiate toward that end when conditions warrant.

In Article 6 of the NPT, signatories undertake to pursue negotiations in good faith on effective measures relating to cessation of the nuclear arms race. In accordance with this, the US is actively pursuing negotiations in Geneva at this time with the objective of preventing an arms race in outer space and terminating it on earth.

VERIFICATION

Senator KENNEDY. Mr. Adelman, in your opening statement, you correctly acknowledge that the unratified PNET contains provision within its protocol for the emplacement of instrumentation equipment at Soviet test sites quite similar to the CORRTEX equipment that the Administration describes as a verification "breakthrough." However, you imply that the obstacle to TTBT acceptability now is that it does not contain a similar protocol. Have you specifically asked the Soviet Union to add verfication provision similar to those in the PNET protocol to the TTBT? Would this action be sufficient to remove your concerns with regard to the TTBT and submit it for ratification?

Mr. ADELMAN. We place top priority on the achievement of a reasonable and effective system by which we can verify compliance with the 150 kt limit of the Threshold Test Ban Treaty (TTBT) and the Peaceful Nuclear Eplosions Treaty (PNET). The US has made a series of concrete proposals to the USSR in this regard.

The President had indicated that if the Soviet Union would join us in an agreement for effective verification including the use of CORRTEX, the US would be prepared to move forward on ratification of the TTBT and PNET.

Senator KENNEDY. In light of the CIA's recent revision of the yield to seismic magnitude correlation, has the administration revised its estimate of the number of alleged Soviet violations of the TTBT? Is the administration going to pursue the recommendation of the CIA that the method for calibrating the yield of Soviet tests be revised?

Mr. ADELMAN. We haven't changed our methodology for estimating yields of Soviet tests. As part of the verification business, we are constantly refining our techniques in an effort to improve our understanding of Soviet testing activities. There has been no change in our findings that a number of Soviet tests have likely violated the 150 kt ceiling of the Threshold Test Ban Treaty.

The U.S. Government in order to protect intelligence sources and methods continues to treat the details of Soviet yield assessment as classified.

Senator KENNEDY. From what we know about Soviet nuclear weapons designs, do you believe the United States is ahead or behind the Soviet Union in key warhead design areas, such as yield-to-weight or yield-to-volume ratios?

Dr. KERR. There are a variety of measures that relate to the sophistication and effectiveness of nuclear weapons. Yield-to-weight and yield-to-volume are two that have been important to the United States since our strategic ballistic missiles have always been throwweight limited compared to Soviet forces. The issue is not whether or not the Soviet Union is ahead or behind relative to U.S. measures of sophistication. Simply stated, the Soviet Union understands the technologies involved in nuclear weapons design and engineering and uses that knowledge to fulfill its military objectives.

Senator KENNEDY. Wouldn't continued testing by the Soviet Union allow them to continue to improve the design of their weapons in ways that would be detrimental to U.S. security?

Dr. KERR. Continued testing would permit the Soviet Union to improve and modernize their nuclear weapons. That fact alone does not mean such modernization would be detrimental to U.S. security since some efforts could be focused on desirable features like improved safety and security while others might lead to destabilizing results.

Senator KENNEDY. Many of our strategic weapons (MX, Trident II, Minuteman III (MK12A) are designed to explode at yields well above 150 kt. Yet, we can only test parts of those weapons that will generate yields below 150 kt. How do we assure the reliability of these weapons if we can't test them as a whole?

Dr. KERR. The nuclear designs for MX, Trident II (D5), and Minuteman III (MK12A) were developed and tested at their full yield prior to the imposition of the 150 KT TTBT limitation. Their stockpile certification is, or will be, based on that testing.

Senator KENNEDY. Is it true that the primary safety feature of nuclear warheads which prevent inadvertent detonation, Permissive Action Links (PALS), do not re-

quire nuclear testing for their development or emplacement. What safety features of nuclear warheads require further nuclear testing?

Dr. KERR. Some older types of Permissive Action Link (PAL) systems do not require nuclear testing for their development and emplacement. Other PAL designs and enhanced safety features are intimately associated with the nuclear system and its functioning thus testing is required for their development. A good example is the introduction of so called insensitive high explosive formulations to ensure safety of aircraft delivered weapons.

X-RAY LASER

Senator KENNEDY. Dr. Bethe, are you familiar with the administration's development and testing of new concepts for nuclear driven directed energy weapons called "nuclear-pumped x-Ray Lasers"? In your view, how may years are we away from being able to "weaponize" the nuclear-pumped X-Ray laser concept?

How many tests would you estimate will be required to develop this concept to the weapons stage?

Dr. BETHE. I am familiar with the development and testing of nuclear pumped X-Ray lasers. It is difficult to answer your question because this development is in its infancy. It is not at all clear whether any amount of testing will lead to a militarily useful X-Ray laser. If there is success at the end of the road, I estimate that between 10 and 20 years of testing will be involved. I would estimate the necessary number of tests, for research as well as development, to be 30 to 50. But Dr. Selden of Los Alamos, who has more experience in testing, estimates 100–200.

RELIABILITY

Senator KENNEDY. Dr. Bethe, one primary argument by test-ban opponents is that our warheads would not be easy to remanufacture if there were stockpile degradation under a CTBT. Assuming that this is true, if DOE had sufficient congressional funding could it supply the necessary equipment, materials, and production techniques that would permit remanufacture of an existing, well-tested warhead using the original design and product specifications?

Dr. BETHE. In my opinion, with sufficient funding, the weapons laboratories (Los Alamos, Livermore and Sandia) could remanufacture the existing, well tested warheads using the original design and production specifications. This applies both to the metal parts and to the high explosive. Nuclear weapons laboratories are very expert in all the techniques involved. They do not usually go into mass production of weapons, but if exact reproduction of existing designs is necessary, they would probably be very well able to do so.

[Whereupon, at 6:14 p.m., the committee adjourned, subject to the call of the Chair.]

Some Little-Publicized Difficulties With a Nuclear Freeze

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PREPARED BY DR. J.W. ROSENGREN, R & D ASSOCIATES, UNDER CONTRACT TO THE OFFICE OF INTERNATIONAL SECURITY AFFAIRS, U.S. DEPARTMENT OF ENERGY

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I. INTRODUCTION

Various persons in the United States and elsewhere have proposed a seemingly simple beginning to further arms control--a "mutual, verifiable U.S.-Soviet nuclear-arms freeze." The present movement for a nuclear freeze received early promotion with the brief tract Call to Halt the Nuclear Arms Race by Randall Forsberg, first published April 1980 by the Institute for Defense and Disarmament Studies. This was expanded in the November 1982 issue of Scientific American in an article by Forsberg, "A Bilateral Nuclear-Weapon Freeze." Further writings have included a report entitled "Model Freeze," which appeared as the September 1982 issue of F.A.S. Public Interest Report, a journal of the Federation of American Scientists. A more recent discussion is presented in Seeds of Promise (published by Brick House Publishing Company), which is mainly a transcript of hearings in September 1982 organized by the Federation of American Scientists.

To persons who are not well-informed on many aspects of nuclear weapons, the proposed freeze appears to offer a simple, safe start toward desirable future reductions in nuclear arms. Actually, it does not. There are a great number of difficulties and hazards that would accompany the freeze as proposed--difficulties in negotiability, verification, and in the resulting strategic balance. This paper will put aside most of these serious, probably fatal, difficulties with the proposed freeze and discuss only one limited but potentially crucial aspect--the maintenance of a reliable nuclear weapon stockpile.

II. THREE PARTICULAR BANS PROPOSED FOR A FREEZE

Three particular, interrelated bans relative to nuclear warheads have been put forward as parts of a freeze. The bans are three of the several freeze components presented in Call to Halt the Nuclear Arms Race and are stated or implied components of most other freeze proposals. These three propositions are individually impractical, and in combination, they present significant dangers. These proposed parts of a nuclear freeze would ban:

(1) any production of weapon-grade nuclear material for weapon purposes;

(2) any manufacture of nuclear weapons, and

(3) any tests of nuclear explosives.

To most non-specialists these prohibitions would appear reasonable and desirable. They seem to be plausible means to prevent the addition of further weapons to the U.S. and Soviet inventories. But, there are important objections that relate to a vital precaution for the U.S. in arms control: the U.S. should avoid any important loss of its ability to deter nuclear attack or major war. These three particular proposed bans could actually promote unilateral disarmament by the U.S. and potentially dissipate U.S. deterrence of the Soviet Union.

The basic problem with the three proposed bans is that they severely undercut the capability of the U.S. to maintain a reliable nuclear weapon stockpile. Judging from past experience, we can expect that, with time, significant uncertainties will arise about the operability of many nuclear weapons in stockpile. Worse than that, there could arise the definite certainty that some particular weapons

would not operate, perhaps all weapons of a particular type. If the U.S. cannot maintain a reliable nuclear stockpile, it is unlikely that the U.S. can maintain a dependable strategic deterrent.

The problem is simple: nuclear weapons are very complex devices that are perishable; they deteriorate and become inoperable. U.S. experience has been that often nuclear weapons must be rebuilt to be maintained in operable condition. This rebuilding of nuclear weapons requires the same sort of facilities as are used in their initial manufacture. The maintenance and operation of such facilities would be banned under the proposed freeze on production of nuclear weapons.

To correct some problems found in stockpile, there may be need to add further nuclear material to a weapon type. The production of this weapon-grade nuclear material would not be permitted under the proposed freeze on the production of nuclear material for nuclear weapon purposes.

Adequate assessment of deterioration that is observed in stockpile and assessment of possible corrective measures can at times require nuclear tests. Weapon experts have stated that the U.S. cannot maintain a reliable nuclear weapon stockpile without the opportunity to test, an opportunity that would be foreclosed under the freeze on testing of nuclear weapons.

All of these requirements for maintenance of a reliable stockpile would be denied the U.S. under the proposed freeze: there would be no production of weapon-grade nuclear material for weapon purposes, no facilities for fabrication of nuclear weapons (and so no facilities for re-fabrication of nuclear weapons), and no testing of nuclear explosives. The sections below consider these

prohibitions in more detail and point out their incompatibility with maintaining a reliable deterrent. In this, the discussion draws on some important past examples of problems with the U.S. nuclear stockpile.

III. THE PERISHABILITY OF NUCLEAR WEAPONS

1. GENERAL

Like other, very much simpler equipment such as automobiles and home appliances, nuclear weapons deteriorate with time. For nuclear weapons, it is not necessarily a matter of "wearing out": they are required to operate only once. There is essentially no wear except for that associated with their transport and handling. However, like some home appliances that have been stored unused in a family's basement, when they are closely inspected they may be found to have deteriorated into an unusable condition.

This susceptibility to deterioration tends to be much higher for nuclear weapons than for other equipment. Various features of their design must be guided mainly by the desired weapon performance and by safety considerations rather than by demands for resistance to deterioration. Many of the weapon materials have a low resistance to deterioration. Certain chemically reactive materials are inherently required in nuclear weapons, such as uranium or plutonium, high explosives, and plastics. The fissile materials, both plutonium and uranium, are subject to corrosion. Plastic-bonded high explosives and other plastics tend to decompose over extended periods of time.

Deterioration can take various forms: portions of materials can dissociate into simpler substances. Vapors given off by one material can migrate to another region of the weapon and react chemically there. One potential source of effluent is the thermonuclear fuel lithium deuteride, which can react with water vapor and release hydrogen gas. Materials in the warhead electrical system such as insulators, batteries, capacitors, squibs, and lubricants can produce effluents that can migrate to regions in the nuclear explosive portion of a weapon.

Over an extended period of time, plastic components in the explosive portion of a weapon can be the source of effluents. These components include plastic-bonded explosives and plastic pads and cushions. The plastics may decompose, or they may give off gases with which they were impregnated during production processes.

As one form of deterioration, corrosion can create fissures and perforations that would have undesirable effects on weapon operation. Mechanical components can have unacceptable friction introduced by corrosion or by other chemical effects. Corrosion products can flake off the surface of some components, and vibration and other movements of the weapon can distribute these flakes ("dust") to locations where they could spoil the weapon's operation.

The characteristics of high explosives can change with time. Materials can creep and become distorted. Vital electrical components can change in character; electrical circuits can open or become shorted. Some changes can be such that they will obviously cause a weapon to dud; other changes can be more subtle, and their effects on weapon performance can be difficult to predict.

The weapon developers have seen and studied many past examples of deterioration and have applied what they have learned to the detailed design of new weapons. However, while the materials scientists and weapon engineers have given great attention to improving the resistance of weapons to deterioration, there is no means to prevent it absolutely. In any event, many examples of earlier technology will remain in the stockpile.

Despite efforts to lengthen the service life of weapons, there is general agreement that an effective life of more than 20 years or so is doubtful and that some weapons may

show unexpected early deterioration, as has happened in the past. As matters stand, many of the weapons in stockpile are approaching an age where their continued ability to function will become increasingly questionable.

2. RESPONSES TO DETERIORATION

Past U.S. practice has been to monitor the nuclear stockpile closely in order to detect any deterioration at an early stage. This monitoring involves a regular sample inspection of samples of each weapon type in stockpile. This requires the disassembly of a weapon and the inspection of its internal components. The disassembly is not simple; it is not a matter of undoing some bolts and screws to separate the various parts. U.S. nuclear warheads in large part are brazed, welded, and cemented together. To disassemble a modern weapon is to destroy it; many portions have to be machined apart. Few of the components could be reassembled and used again in a rebuilt weapon. Generally only the nuclear material is worth recovering, and the fissile material usually must be melted down if it is to be refabricated into a weapon.

The weapon-sampling operations in the U.S. have involved considerable use of the weapon production facilities. The initial major disassembly is done at the complex of facilities that are used for final assembly during weapon production. Component parts are then usually disassembled elsewhere, likely at the facilities where they were originally assembled. In this way, the handling fixtures, gauges, and other equipment used in the production of the weapons are potentially available for use in the disassembly and inspection operations.

While there is no absolute requirement that the same facilities be used for weapon disassembly and inspection that are used for weapon production, there are distinct benefits and conveniences from this dual use. There would probably be no achievable arms-control benefit from requiring that the facilities be different. Adequate stockpile sampling requires substantial facilities for the disassembly and inspection operations. If such facilities are permitted, they could potentially be used clandestinely for production of new weapons. Certainly, such facilities could not be well monitored: it is unimaginable that stockpile-sampling operations would be opened to inspection by foreign personnel.

3. TESTING

Leaving aside the development of new warheads, the U.S. needs a nuclear test program in order to monitor and maintain the U.S. nuclear stockpile effectively. Such tests, which would be banned under the proposed freeze, would at times be required to determine the effects of the deterioration that is observed and to evaluate possible corrections of the weapon design. Weapon scientists may propose design changes in order to ameliorate the effects of the deterioration without a complete rebuilding. If a major rebuilding is necessary, the weapon scientists may need to alter the design in order to avoid an early repetition of the deterioration. Any design changes present some degree of uncertainty, which may need to be resolved by nuclear test.

If U.S. weapon scientists observe serious deterioration when there is a prohibition of nuclear testing, the possibilities for effective response would be much more

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limited and more uncertain than they would be with nuclear tests. Unless there were strong reason to do otherwise, the weapon managers would need to accept the worst credible estimate of the consequences of the observed defects and to respond accordingly. For deterioration that potentially would reduce the yield significantly, the DoE would need either to substitute a different model warhead or to rebuild the existing model. Either choice demands new weapon production, which is inconsistent with the proposed freeze.

The substitution of a different warhead would probably involve a great time delay. To use another warhead model requires adapting that model to the particular carrier vehicle. Such adaptation usually necessitates a considerable development program--for example, one that requires developmental flight tests, which are not permitted under the proposed freeze. The adaptation of a different warhead would almost assuredly demand changes to that warhead,* which could introduce considerable uncertainty if there are no nuclear tests.

If serious deterioration is observed among a particular type of warhead in stockpile, the most likely response during a ban on nuclear testing would be to retrofit the stockpile by producing a new version of the same warhead. However, the weapon managers would probably elect to make some changes to avoid early reappearance of the same deterioration. No doubt they would make as minor changes

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* If weapon engineers are to package a nuclear warhead into a new environment, such as a different carrier vehicle, they usually need to make changes to mounting structures, which can affect weapon operation. They also usually need to alter the warhead interior if it has to withstand any increase in the harshness of the warhead environment, such as higher g-loads (accelerations), higher or lower temperatures, or more-intense vibrations.

as possible, since any change will introduce some uncertainty. Weapon-design experts would be called on to evaluate the proposed changes to determine their effect on warhead performance. Presumably, the changes would be limited to ones that the experts certify to have almost zero effect, but such certification is unlikely to be possible without some accompanying uncertainty.

4. SOME DIFFICULTIES IN REBUILDING WEAPONS

Even if the responsible weapon organizations decide to produce duplicate warheads without any changes, they are likely to find that impossible. Various difficulties are likely to arise in attempting to produce new examples of an old weapon design. One probable difficulty is that complete-enough documentation of the earlier production will not be available. For example, some materials may not be characterized adequately. Material properties can depend on minor impurities and on details of the past processing of the material. For many materials, there may not be sufficient documentation of the processing that their properties can be closely reproduced.

It might be said that one need not describe the material itself completely; that, instead, one need describe only its required performance. However, it is probably not feasible to do that in useful terms. The performance required is, of course, that which would lead to proper overall nuclear operation of the weapon, which can be confirmed only by nuclear test. Measurements in the laboratory of partial, non-nuclear phases of a weapon's operation cannot go far in confirming correct overall performance.

Another possible difficulty in reproducing weapons comes from the fact that proprietary commercial products may be used in their production. The original production may have

used one particular batch or formulation of a commercial product, and that formulation may no longer be available after many years. For various reasons, the specifications of commercial products change with time.

Still another possible difficulty is that certain materials may no longer be available because their handling or production is impractical under new OSHA rules. Some materials in weapons are potentially carcinogenic, others are toxic. Some have become subject to tighter and tighter controls, with their continued practical availability becoming questionable.

In addition to problems in reproducing materials, there are other problems in replicating components. Some components represent subtle fabrication technologies that were put aside years ago. To reproduce them now could require the reinvention of an old, outmoded technology. There would be great impetus to go to new, "superior" components, instead of attempting to reproduce old, outdated components.

5. UNCERTAINTIES WITHOUT NUCLEAR TESTS

All of these difficulties in replication mean that there are likely to be a variety of subtle, poorly known differences and perhaps some clear, intentional differences between old and new versions of a given weapon type. If a nuclear test of the new version is not possible, there can be serious uncertainty about its performance, including in some instances the possibility of its giving no appreciable yield.

Some proponents of a freeze would argue that such uncertainty would be acceptable, if not actually desirable. They presume that the Soviets would be subject to similar uncertainties about Soviet weapons. Freeze advocates argue

that, with uncertainties in the performance of its weapons, each nation would be less likely to launch a first strike. In addition, some argue that if the U.S. were uncertain that U.S. weapons would operate successfully then assuredly the Soviets would also be uncertain about U.S. weapons. Not knowing definitely that U.S. weapons would not operate adequately, the Soviets would still be deterred.

These arguments, as presented, ignore various possible dangerous situations that could arise in place of the assumed safe symmetry. It may be that uncertainties would develop much earlier and more extensively with the U.S. weapons than with the Soviet weapons. In some circumstances, there may come to be clear evidence that certain U.S. weapons will not operate correctly, evidence that with time would become known to the Soviets.

While this paper will not consider the difficulties of verifying Soviet adherence to a freeze, it can be noted that the Soviets would be able to cheat in many ways, including the clandestine testing of their nuclear weapons. For example, past U.S. studies indicate that it would be feasible for the Soviets to test in space, up to very high yields, without detection, and it is conceivable that the Soviet Union has already confirmed that feasibility by conducting such tests. Nuclear tests by the Soviets and other possible asymmetries in observance of a freeze could allow the Soviets to retain full confidence in their stockpile while the reliability of the U.S. stockpile deganerated.

IV. SOME PAST EXAMPLES OF STOCKPILE PROBLEMS

1. INTRODUCTION

The sections above note, in general terms, difficulties that can occur with nuclear weapons in the U.S. stockpile. Here, we review some specific past instances of stockpile problems. Our choice of illustrative examples has been limited by security considerations, and in the discussion below, we have had to avoid various items of classified information. Nevertheless, the information that can be presented can provide some lessons. For the first examples, we consider the nuclear warheads of the Fleet Ballistic Missile System (FBM), which have had a series of problems in the past.

Freeze advocates often stress the importance of the U.S. ballistic missile submarines, which are presented as being, at present, an assuredly invulnerable and reliable force--a force that would help make a nuclear freeze advantageous and safe for the U.S. In actuality, at times in the past the warheads for a large part of the U.S. FBM force have been found to be badly deteriorated. At different times, a large fraction of the warheads either obviously or potentially would not work; they were obvious or potential duds. Under the restrictions of a nuclear freeze, as proposed, these situations would have become desperate, because there would have been no means to rehabilitate the FBM force.

2. PROBLEMS WITH THE FIRST POLARIS WARHEAD

Some early difficulties occurred with the first Polaris warhead, the W47, now retired. In scheduled surveillance of W47 warheads in stockpile in December 1961, weapon engineers observed that significant corrosion had occurred in the fissile material of the weapon. This observation and

subsequent inspection of additional W47 warheads indicated a possible problem with the yields of the stockpile weapons. There was the possibility that some weapons would give only a trivial fraction of their rated yield.

To obtain a dependable estimate of the resulting stockpile capability, the Atomic Energy Commission (AEC) conducted an underground nuclear test in Nevada. The test device was a modified W47 with man-made alterations of the fissile material to represent an extreme example of the corrosion that had been observed. The weapon scientists measured the yield to be somewhat low but still in an acceptable range. This satisfactory test result restored confidence in the W47 stockpile and permitted a limited, non-urgent retrofit program.

In the retrofitting, weapon engineers inspected each warhead by means of radiographs at a convenient time in the Polaris operations schedule. As a result, the AEC replaced 20 percent of the W47 warheads in stockpile with new production and made a slight design change in all the W47 warheads to prevent further similar corrosion.

In this instance of deterioration, the capability to conduct a nuclear test allowed the weapon scientists to respond in a moderate manner. Without a test, it could have been argued that all the weapons would be duds, and seemingly there would have been a need for an urgent rebuilding of all the W47s. A test allowed a less urgent, far more limited response.

A later, more difficult, problem with the Polaris W47 warhead grew out of certain earlier restrictions on nuclear testing. The weapon was put into stockpile during the nuclear-test moratorium of 1958-1961, without having had enough tests to fully resolve certain design problems. The

particular troubles that we recount here eventually had to be cured by further nuclear tests.

Nuclear tests conducted shortly before the 1958-1961 moratorium were insufficient to provide an inherently one-point-safe* warhead in the Polaris Mk 1 reentry body. The situation arose because of a surprise result in a nuclear one-point-safety test of the W47 just before the moratorium. Instead of giving negligible yield, the test gave about one hundred tons yield. To counter this safety problem, the Livermore warhead developers provided a mechanical one-point-safety arrangement. Production of the W47Y1 warhead with this mechanical safing system began in May 1960.

During surveillance sampling of the W47 stockpile in 1963 (after the end of the moratorium), weapon engineers discovered in some sample weapons that the mechanical system did not fully complete its arming operation; this lack of complete arming would result in a dud weapon. The engineers attributed this failure to a growth in friction caused by some chemical reactions on the surfaces of components, to some crimping of one component during production, and to marginal power in the driving motor. The engineers were able to resolve this early problem with the safing mechanism by radiographing the W47 stockpile for evidence of crimping and by installing a more powerful motor. This was an

* A nuclear weapon that is "one-point-safe" has a negligible probability of giving any appreciable nuclear yield if detonation is initiated at any one point in its high explosive system. (A one-point detonation is to be contrasted with correct, intentional detonation initiated by means of the firing set.)

example of a stockpile problem where the cure did not require nuclear test. However, as matters turned out, the cure was not effective against certain later instances of deterioration.

Beginning in February 1963, a new version of the W47 began to enter stockpile, supplementing the old version, which remained in stockpile. The new version, the W47Y2 Mod 2, had the same mechanical safing system, but the warhead yield was higher, and the character of some of the fissile material was changed. In August 1965, in the first stockpile-surveillance (non-nuclear) test of the arming operation in the new-version warhead, the mechanical safing system operated only halfway, which would have dudded the weapon. This failure appeared exceptional, because in further tests both the old and new versions operated successfully. Nevertheless, concern remained when, even after a year of investigation, there was no agreed-upon explanation of the observed failure. This concern proved justified when further tests of the mechanical safing system in late 1966 resulted in additional failures with the new-version warhead.

From the time of the first failure in 1965 until early 1967, the weapon scientists concentrated great attention on assessing the Polaris warhead problem and finding a reasonable explanation and cure. They were unable to find a clear, full explanation. (There is still no completely satisfactory explanation.) Friction appeared to increase in the safing system as it aged, with more-rapid increase in the new-version warhead but with evidence that the old version would eventually also show failures.

At the time of this stockpile problem, three quarters of the W47 warheads were the new version. The observed failure rate was about three-out-of-four for the new version and, at that time, zero for the old version. Based on these observations, the overall failure rate for W47 warheads would have been about 50 percent. This rate would no doubt have become worse with time, possibly approaching 100 percent, with failures in the safing systems of even the old-version warheads.

Proposed engineering fixes were questionable. For example, there appeared to be no compatible lubricant that could be added to improve operation. Tests of proposed "improvements" also showed failures. Because of the on-going engineering difficulties, the weapon scientists sought a solution by means of nuclear tests. They first tested the new version for inherent one-point safety, without the mechanical safing system. A yield of about one hundred tons showed that, indeed, even the new version of the W47 was not inherently one-point safe.

Earlier, a nuclear test of a different, but similar, warhead had shown that warhead to be inherently one-point safe. The Livermore designers proposed to modify the W47 to give it certain features of the other type warhead. This they were able to do when new nuclear tests showed that the redesigned W47 without mechanical safing would be both one-point safe and capable of proper full-yield operation. The AEC proceeded to rebuild the entire W47 stockpile, converting all warheads to the revised version, W47Y2 Mod 3, by late 1967.

If the above problems with corrosion and with operation of the mechanical safing system had been discovered under the conditions of the proposed freeze, they could not have been solved while the freeze continued. The weapon scientists

would not have been able to conduct a nuclear test to assess the effects of the observed corrosion in the fissile material; they would not have been able to conduct a nuclear test to evaluate their proposed solution to the problems with the mechanical safing system; and they would not have been permitted to rebuild the warheads.

It is to be noted that the freeze would have presented a still further impediment to the solution: without production of reserve nuclear material, the W47 could not have been converted to the Mod 3 design. That design version required the addition of more weapon-grade plutonium, the production of which would be banned under the freeze.

3. PROBLEMS WITH THE SECOND POLARIS WARHEAD

The precarious circumstances described for the Polaris W47 have not been the only difficulties with warheads for the Fleet Ballistic Missile System, and further difficulties have not been confined to the distant past. For example, during the 1970s, there were problems with corrosion in the W58 warhead for the later Polaris Mk2 reentry body. The AEC (later ERDA) and the Navy were able to counter these problems by certain minor changes to the warheads at Navy maintenance facilities, without any further nuclear tests being required or any major rebuilding.

4. PROBLEMS WITH THE FIRST POSEIDON WARHEAD

More recently, there were problems with the warhead for the Poseidon missile that were solved by a major rebuilding of the entire Poseidon stockpile, thousands of warheads. The warheads in trouble were the W68 warheads developed by the Lawrence Livermore National Laboratory (LLNL) for the Mk3 reentry bodies carried by the Poseidon C-3 missile.

The AEC began production of the W68 in 1970 and ended its original production in 1975. As we noted earlier, weapon scientists closely monitor the health of weapons entering and residing in stockpile. Over a seven-year period, as part of the stockpile-reliability program, Livermore scientists dismantled and evaluated portions of about one hundred W68 warheads. The weapon scientists found that the mechanical properties of the high explosive in the warhead degraded with time and that the high explosive began to give off a distinct odor, indicating some chemical change. Effluents from the high explosive interacted with other materials: the mechanical properties of a plastic component near the high explosive changed, and a uranium-alloy component close to the high explosive developed corrosion spots. These changes alone would not have caused the warhead to fail, but there was another associated change that did become a concern: effluents from the high explosive interacted with the adiprene adhesive in the detonators, causing it to soften. The Livermore scientists feared that products from this reaction could interact with the detonator bridgewire and eventually cause the detonator to fail.

In the time period 1977-1979, Livermore, in conjunction with ERDA (later DoE) and the Navy, evaluated the W68 situation more fully and considered possible remedies. Early in the development program for the W68 there had been two candidate high explosives for the weapon; these were LX-09, which was adopted, and LX-10. LLNL had fired two successful W68 development tests with LX-10, and the high explosive had performed adequately. Even after eliminating LX-10 from the W68 program, the Livermore scientists had continued to develop and evaluate it. By the late 1970s, the scientists were confident that LX-10 was free of the problems that were then appearing with the LX-09.

In 1979, on LLNL's recommendation, the DoE and DOD agreed to a complete time-phased retrofit of the W68 stockpile. The DoE weapons-production complex rebuilt all the W68 weapons, a few thousand, replacing the LX-09 with LX-10.

On the basis of the earlier nuclear tests, LLNL was confident of the reliability of the modified warheads, and the Laboratory did not require a new nuclear test. However, as a "final development test," LLNL did test the W68 again after the retrofit. In the test, LLNL used a weapon that was in many ways at the edge of acceptable tolerances and that had one limited-life component with an age that was over that of any to be used in stockpile. This extreme test device performed successfully, confirming the Laboratory's confidence.

The above examples of stockpile problems involved some of the most important strategic military systems of the U.S. The Polaris system and its successors, the Poseidon system and the Trident system, have constituted what arms-control experts consider the most crucial unit of the U.S. strategic triad. This sea-based component, which complements the land-based-ICBM and strategic-aircraft components of the triad, has been considered the least vulnerable unit of the three, hence the most survivable strategic force. However, as the above examples indicate, this force is susceptible to possible disablement under the proposed conditions of a freeze.

5. PROBLEMS WITH A MINUTEMAN WARHEAD

Difficulties do not arise only with the strategic warheads that are carried in the sea-based portion of the U.S. strategic triad. Problems have also occurred with the

warheads for the land-based ICBMs. For example, in late 1963 the AEC had to rebuild all the W56 warheads of the Minuteman ICBM force.

The W56 warhead, like the Polaris W47 warhead, developed problems in stockpile with a mechanical component associated with arming operations. The weapon engineers discovered the W56 problems sooner and were able to resolve them more easily and quickly than was possible with the mechanical problems of Polaris.

LLNL developed the W56 warhead for the Minuteman Mk11 reentry vehicle in large part during the 1958-1961 test moratorium, when the Laboratory could not test the nuclear device. For certain reasons related to the inability to test, LLNL provided a mechanical arming arrangement as part of the basic nuclear structure.

In 1962, shortly after the end of the moratorium, LLNL successfully conducted nuclear tests of the W56 developmental design with its mechanical arming component, and the first production unit entered stockpile in March 1963. As part of a regular stockpile monitoring program, weapon engineers subjected certain W56 components to non-nuclear tests and found problems in stockpile with the mechanical arming component. In several tests, the arming mechanism did not fully complete its operation, presenting the possibility of duds. This was after the AEC had produced over one hundred warheads.

In a reasonably short time the weapons engineers were able to arrive at an acceptable redesign, one that had so little change that it did not require evaluation in a nuclear test. By the time the weapon engineers completed the redesign and the AEC could begin the retrofitting, over 160 weapons needed to be returned from stockpile to be

rebuilt. That redesign has stood the test of time: further stockpile sampling has not shown any problems with the W56 arming mechanism.

6. PROBLEMS WITH THE W45 TACTICAL NUCLEAR WEAPON

Past instances of deterioration and other problems in the stockpile have not been limited to the warheads for strategic nuclear systems. Probably all types of nuclear warheads, including those for tactical weapon systems, have exhibited some degree of deterioration, leading in some instances to serious difficulties. Examples of problems with tactical nuclear weapons can be found in the history of the W45, which was the warhead for Little John, once a tactical missile of the U.S. Army. The W45 is still the warhead for both Terrier, a U.S. Navy surface-to-air missile, and the Army's and Marine Corps' atomic demolition munition (ADM).

In separate periods during the career of the W45, weapon engineers have discovered significant deterioration in the W45 stockpile. In surveillance of that stockpile during the early 1960s, weapon engineers found serious corrosion of the fissile material in W45 warheads. The corrosion was altering the geometry of the weapon enough to raise considerable question about the continued operability of the weapons. The AEC instituted a substantial review program in which weapon engineers inspected each W45 in stockpile and, using a criterion based on a related nuclear test, eliminated many of the corroded warheads from stockpile. For the units remaining in stockpile and for new production units, weapon scientists made certain design adjustments that have proved to provide adequate long-term protection against further similar corrosion in the W45.

In about the same time period, the engineers found dimensional changes in W45 weapons due to creep in the high explosive. To counter this problem, the AEC conducted a retrofit program in which LLNL engineers and scientists modified the warhead design, and the production plants rebuilt every W45 in stockpile.

Because the W45 was incorporated into three different weapon systems, and because individual systems needed more than one yield option, there were various yield versions of the W45. Early in the career of the W45, LLNL tested it under circumstances that were similar to those of an earlier test but with certain small changes that occur with aging in stockpile. The result was a rude surprise: the test device gave only about half its rated yield.

Because of this unexpected result and because of the design changes in the W45 retrofit programs mentioned earlier, LLNL tested the W45 in a series of five underground nuclear events in the mid 1960s. It was only on the basis of actual tests that the AEC and the military services could have confidence in the performances of the various yield versions at different stockpile ages.

7. PROBLEM WITH THE SERGEANT W52 HIGH EXPLOSIVE

The W52 was a thermonuclear warhead for the Army's now-retired Sergeant surface-to-surface tactical ballistic missile. The warhead design was being readied for production when two fatal accidents occurred in 1959 at what is now the Los Alamos National Laboratory (LANL), killing a total of four people. Both accidents involved large pieces of high explosive of the type to be in the W52. The two explosions revealed an unexpected susceptibility to accidental detonation of large pieces of that particular high explosive.

The pieces of high explosive to go into the W52 were also large, like the pieces in the accidents. For reasons of safety, especially during production, Los Alamos decided to change the HE system in the W52 to a less-sensitive high explosive, which was also somewhat less energetic. The Laboratory staff made this decision during the nuclear-test moratorium, 1958-1961, when they could not test the new design in a nuclear event. The weapon scientists based the redesign on non-nuclear hydrodynamic (high explosive) tests in the laboratory and on the results of calculations with computer programs. They had high confidence in the revised warhead, despite the lack of a new nuclear proof test.

After U.S. nuclear testing resumed in late 1961, Los Alamos gave higher priority to other test objectives than to a test of W52. This in part was because of the high confidence that the Laboratory had in the W52 redesign, which began to enter stockpile in April 1962. After more than a year of tests of other nuclear devices, LANL in early 1963 tested a partial-yield version of the W52. Proper performance of the partial-yield device would indicate, but not prove, proper performance of the full-yield weapon. On the other hand, poor performance of the test device would show that the full-yield design would not perform adequately. The result was calamitous: the test device gave only a small fraction of its expected yield. From the results of the nuclear test it was apparent that instead of the Sergeant missile system having its rated yield, its nuclear explosive energy would be only about one percent of that value, and the system would be militarily useless.

To restore the Sergeant system to its previously rated yield, Los Alamos scientists made a rapid redesign and added substantially to the content of special nuclear material. Within three months after the surprise test failure, Los

Alamos scientists tested the revised design, again in a partial-yield version. This time the nuclear test result was satisfactory, and the AEC replaced the W52 stockpile with the new design.

The problems with the Sergeant nuclear warhead were a severe example of potential difficulties with the stockpile if nuclear tests are not permitted. Before the corrective actions that resulted from the nuclear-test failure, every Sergeant nuclear missile was without any effective capability. Without the nuclear test, this ineffective version of the Sergeant force would have grown in number and remained deployed for years. The difficulties with the W52 warhead provide a dramatic illustration of the limitations of non-nuclear experiments and computer programs in the evaluation of even moderate changes in nuclear warhead designs.

V. CONCLUSIONS

1. INTRODUCTION

The past examples noted above of serious problems with nuclear weapons in the U.S. stockpile point up some of the basic deficiencies of the proposed nuclear freeze. Each of the three particular proposed prohibitions discussed here presents immediate difficulties and potential serious risks. These difficulties cannot be regarded lightly, nor can they be considered desirable on the basis that they will occur for both the U.S. and the Soviet Union. Acceptance of the prohibitions leaves too much to happenstance and to unknown characteristics of the weapons of both nations. The extent of possible asymmetries between the U.S. nuclear weapon program and that of the Soviet Union is not definitely known to U.S. intelligence organizations. For example, the U.S. nuclear weapon systems may be far more susceptible to difficulties than are Soviet systems.

The occurrence of stockpile problems is to a large extent a matter of unknown probabilities; specific examples cannot be foreseen. For the U.S. to agree to do away with the means to respond to stockpile problems is to take the risk that the U.S. by chance will become far more weakened by the proposed prohibitions than will the Soviets. Beyond possible asymmetries that may result by happenstance or from basic differences in U.S. and Soviet weapons, there are definite possibilities of asymmetry by cheating. If in secrecy the Soviets violate the agreed prohibitions, they might maintain their weapons in known reliable working order while the U.S. weapons deteriorated, possibly in dramatic

ways that become known to Soviet intelligence as well as to the U.S. military. The following sections briefly review the three particular proposed prohibitions addressed by this paper and again note the consequent difficulties.

2. FREEZE ON PRODUCTION OF NUCLEAR WEAPON MATERIALS

A prohibition against production of nuclear material for weapons would present severe problems for the U.S. For one, the U.S. needs to be able to operate production reactors to produce the tritium required to keep its weapons operable. Some freeze proponents have made note of this problem. Call to Halt the Nuclear Arms Race calls for a halt only to the "production of fissionable material (enriched uranium and plutonium) for weapon purposes." Randall Forsberg in her 1982 Scientific American article notes the need to replace tritium components in weapons and states, "This implies that the freeze should allow the operation of tritium-component assembly facilities and the running of perhaps one military nuclear reactor to produce tritium."

The U.S. also needs to maintain a reserve of weapon-grade plutonium. At the very least, this is necessary to permit the rebuilding of nuclear weapons that may require an increase in plutonium-content to correct some problem. The U.S. must operate uranium-isotope separation plants to produce weapon-grade uranium, which is required to fuel the ship-propulsion reactors of the U.S. Navy, including those of the Poseidon and Trident submarines. In addition, if development of breeder reactors is to continue in the U.S. and in the Soviet Union, both nations will need to be able to reprocess reactor spent fuel to separate plutonium. This plutonium, which would be used to manufacture fuel elements for use in breeder reactors, would not be weapon grade, but it would still be usable as the nuclear material in certain types of nuclear weapons.

Some freeze advocates have noted that it can be difficult to monitor any agreed level of production other than a zero level. However, zero levels of production of nuclear materials are out of the question, because of the requirements noted above. One cannot imagine the Soviet Union or other nations agreeing not to refuel nuclear submarines or not to reprocess reactor fuel and, hence, not to operate breeder reactors.

3. FREEZE ON PRODUCTION OF NUCLEAR WEAPONS

A prohibition against the fabrication of nuclear weapons would place unacceptable constraints on the U.S. There would then be no way to respond effectively to deterioration when it is observed in the nuclear stockpile. Again, some freeze advocates have argued that it is important that no nuclear weapon production be permitted. They note that a low level of production would be more difficult to monitor than zero production. Under the proposed freeze there would be no weapon-fabrication facility in operation and, in some proposals, even no weapon-fabrication facility capable of operation.

Such a prohibition of production goes directly against the needs of the U.S. to keep its nuclear weapon stockpile in operable condition and, hence, to maintain deterrence. Even for effective stockpile monitoring the U.S. needs fabrication-type facilities, since stockpile sampling requires carefully controlled machining to disassemble weapons and requires elaborate inspection and gauging equipment.

The U.S. needs to operate weapon-fabrication facilities to rebuild weapon systems that have deteriorated. To keep from revealing serious military deficiencies, the U.S. needs

to keep any serious deterioration secret, at least until it is corrected. For this reason and other reasons, the specific rebuilding itself needs to be kept secret, and the facilities, while in operation, cannot be subject to Soviet or other foreign inspection.

4. FREEZE ON TESTING OF NUCLEAR WEAPONS

A prohibition of tests of nuclear explosives also would seriously inhibit the U.S. in maintaining a reliable stockpile of nuclear weapons. In addition to other reasons for nuclear tests, the U.S. needs the option of nuclear tests to assess the effects of weapon deterioration that may be found. Tests can be needed to determine whether an urgent or moderate response is required and to evaluate possible responses. If the deterioration is serious, all weapons of the type involved may need to be rebuilt or to be replaced by a different type, both of which are likely to require some alterations of warhead design. To make the alterations with confidence, the weapon managers will likely need one or more nuclear tests of the altered warhead.

If the warhead requires replacement by a different type, the replacement warhead will need various certification tests in its new role. It will require at least non-nuclear operational tests in the environment of the carrier vehicle, which could mean developmental flight tests, which are also prohibited under most freeze proposals.

5. OVERALL CONCLUSION

Whatever the other difficulties of a "nuclear freeze," the proposed bans that we have discussed would present great risks to the U.S. Under such a freeze there would be no assurance that major nuclear weapon systems could be kept in

working order. As in the past, serious difficulties with a particular types of nuclear warheads could abruptly become apparent. With bans in effect on rebuilding and testing, the U.S. would have no effective means to rehabilitate the weapon systems.

Any nation faced with that situation would expend great efforts to keep the difficulties secret and would have almost irresistible incentive to violate the bans. While the U.S. would have great difficulty in maintaining the required secrecy and in violating the bans without being detected, there is strong reason to believe that the Soviets could do both. There would be a major asymmetry between the U.S. and the U.S.S.R in the risks involved in entering into such a freeze agreement. The U.S. needs to seek a more realistic, less simplistic, and less risky path to the reduction of tensions between the U.S. and the Soviet Union than the path offered by the freeze proposals.

Chairman FASCELL. Dr. Sykes, you may proceed.

STATEMENT OF LYNN R. SYKES, HIGGINS PROFESSOR OF GEOLOGICAL SCIENCES, LAMONT-DOHERTY GEOLOGICAL OBSERVATORY OF COLUMBIA UNIVERSITY, PALISADES, NY

Mr. SYKES. Thank you, Mr. Chairman, Members of Congress, ladies and gentlemen.

I address you today as a scientist who has been involved in research related to verification of test ban treaties for the past 24 years. I was a member of the U.S. delegation that negotiated the threshold test ban treaty with the Soviet Union in 1974.

I've also been a member of several U.S. Government panels that have examined questions of verification of atomic testing, including the yields of Soviet explosions.

Seismology, my main field of expertise, provides the main tools for verification of a comprehensive test ban and for ascertaining if the Soviet Union has complied with the 150 kiloton limit set by the threshold treaty.

First, I'd like to make the following major points:

Both the threshold test ban treaty [TTBT] and the peaceful nuclear explosions treaty [PNET] can be verified with high confidence.

Second, there is growing preponderence of scientific opinion that the Soviet Union has not violated the 150 kiloton limit of the threshold treaty. In fact, both the United States and the Soviet Union have tested repeatedly close to that limit since the treaty took effect in 1976.

Third, the TTBP and PNET call for extensive exchanges of data when the treaties are ratified. Those provisions would considerably enhance the verification capabilities of the United States.

Fourth, it is in the best interests of the United States that the Soviet Union not test large weapons. Ratifying these two treaties would constrain the Soviet Union by treaty from conducting such large tests. In the absence of such restraints, the U.S.S.R. would probably have an asymmetrical advantage in that it could conduct very large underground tests easier than the United States.

Fifth, a comprehensive treaty is verifiable with high reliability down to explosions of very small size. Recent advances over the past 2 years in seismology insure that clandestine cheating will be easier to detect that was thought only recently.

I believe that the main impediments to a CTBT are neither scientific nor technical but rest on the notion that U.S. security is best enhanced by continued testing and development of new weapons.

I would also suggest that an alternative to a comprehensive treaty is a very low yield threshold treaty with a threshold limitation of about 1 kiloton. Either that or a CTBT would drastically curtail the testing of a so-called third generation of atomic weapons.

Let me turn to Soviet compliance with the threshold treaty.

The United States capabilities for estimating yields of Soviet explosions, and hence verifying compliance with the 150 kiloton limit of the TTBT, have improved greatly over the past several years.

Dr. Jack Evernden of the U.S. Geological Survey, who has also worked in test ban verification for the past 25 years, and I organized a major symposium for the American Geophysical Union 2 years ago.

At that symposium about 500 people heard presentations on whether the Soviet Union was likely to have cheated on the TTBT and how well a comprehensive test ban could be verified. In that day about 15 experts presented their findings, including experts from the Department of Defense, the Lawrence Livermore Weapons Lab, and various Department of Defense contractors working in test ban verification.

There was a consensus among the participating experts, among those attending the symposium and in press coverage that the U.S.S.R. had not cheated on the threshold treaty. Also, scientists from the Lawrence Livermore weapons laboratory as well as those from the United Kingdom and Sweden who have done extensive work on seismic verification do not believe the Soviet Union has cheated.

It is now universally accepted that the correct methodology for estimating yields must take into account the geological and geophysical properties of the outer 100 miles of the Earth directly beneath various testing areas, as well as the properties of the rocks immediately surrounding each explosion.

All of the main Soviet testing areas are on old geological terrains, while most of the U.S. data come from Nevada, a region of recent earth movements and volcanic activity. If these geological effects are not accounted for, the estimated yields of Soviet tests are too large.

I believe that the allegations that the U.S.S.R. has violated the TTBT are—and I also believe that many other seismologists who have studied this problem believe, that those allegations arise solely from an incorrect calibration. The calibration that would relate the seismic waves and turn it into yields of explosions.

When the correct methodology is used it is evident that the Soviet Union has not cheated on the threshold treaty. In addition, it has complied with the peaceful explosions treaty by not detonating explosions above that limit.

The peaceful and threshold treaties both have extensive provisions for verification. The TTBT calls upon ratification for the exchange of data on geological and geophysical properties of testing areas, and for information to be released on the seizes of calibration explosions.

The TTBT states that weapons tests will be conducted at specific test sites. Those provisions will permit the United States to estimate yields of Soviet tests more accurately.

It is known that the sizes of seismic waves detected from explosions vary with the nature of the rock near the explosion point. The provisions of the TTBT were particularly aimed at giving a better calibration of that geological factor, that is, the properties of the material around each test explosion.

It should be pointed out that the United States already can estimate yields with high confidence. When the correct methodology is used it is evident that the yields provided by the Soviet Union for

four of their peaceful explosions are correct and that they have not given us incorrect or misleading information.

The peaceful explosions treaty also has extensive verification procedures, including the first language allowing onsite inspections by U.S. personnel within the Soviet Union. That provision could be extremely important in other arms control agreements of the future, such as a comprehensive treaty.

I'd like now to address the question of verifying a comprehensive treaty. This is certainly one of the longest running items on the arms control agenda. Active interest in it now goes back more than 30 years.

Most seismologists who have been involved in test ban research, like myself, believe that the main technical and scientific impediments to verifying the comprehensive treaty were solved by 1968. The United States has spent about half a billion dollars in this area on research and instrumentation over the past 25 years.

Extensive negotiations toward a comprehensive treaty were conducted among the United States, the United Kingdom, and the Soviet Union from 1977 to 1980. An announced statement by the three indicated that all of the long-contested aspects of verifying such a treaty were resolved at least in principle by 1980, including a moratorium on the testing of peaceful explosions, provisions for U.S. seismic monitoring posts within the Soviet Union, exchange of seismological data, and on-site inspections of the challenge type. Those negotiations have been in abeyance since 1980.

Seismological methods are the main tools for verifying if a country has detonated clandestine underground explosions under a comprehensive test ban. The main problem in seismic verification has been to distinguish the signals of small explosions from those of the many small earthquakes that occur around the world every day. For the United States, of course, the Soviet Union is the prime country of interest in monitoring a test ban treaty.

In our October 1982 article in Scientific American, which I have passed out along with my testimony, Evernden and I made a special study of about 1,000 earthquakes and explosions on a worldwide basis. Once we had eliminated earthquakes outside of the Soviet Union or those deeper than about 15 miles, which is quite a bit deeper than the deepest wells that have ever been drilled, we were left with only a small number of events that were both shallower than 15 miles and within or close to the Soviet Union.

The remaining events constitute only about one-half of 1 percent of the world's earthquakes. In actual numbers this amounts to about 100 earthquakes per year equivalent in size to a 1-kiloton explosion in hard rock, and it's for those remaining events that we must use other diagnostic techniques.

One of the most important contributions of the U.S. program for research in this area was the finding in the 1960's that the excitation of seismic waves of various frequencies was different for earthquakes and underground explosions. Figure 3, on page 15 of my testimony, shows that the long waves from an earthquake are about a factor of 10 to 100 times larger than those from a nearby underground explosion. This ratio is highly reliable in allowing us to identify an event as being either an explosion or earthquake.

In the last 2 years it has been recognized that high frequency seismic waves propogate readily across large parts of the Soviet Union. With a high frequency capability and with seismic monitoring posts in the Soviet Union, as was agreed to in 1980, it should be possible with high confidence to verify even the most strenuous attempts to cheat at a level of 1 kiloton and larger.

Satellite surveillance and other national technical means available to the United States should be a powerful factor in verifying a comprehensive test ban since it would be exceedingly difficult to clandestinely dispose of the huge volume of material that must be excavated to muffle or decouple an explosion of even a few kilotons.

Chairman FASCELL. Unless you pump it full of Jell-O.

Mr. SYKES. Right. Removing that amount of material which for 8 kilotons fully decoupled equivalent to the size of the largest Egyptian pyramid, we are dealing with a huge volume of material that has to be excavated for that scenario to work. Nonetheless, all of us who are working on detection agree that the scenario of big-hole decoupling is the limiting factor in verifying a comprehensive test ban.

The United States has developed and tested instruments, so-called black boxes, that could be installed within the Soviet Union as part of a test ban agreement. Technology in that area has advanced to the point in which data can be transmitted nearly instantaneously by satellite to the United States. Also the devices can be constructed so that they will be tamperproof and we can be certain about the integrity of the data that they record and transmit back to us.

Two of the three reasons given by the U.S. Government in 1982 for not continuing negotiations toward the comprehensive test ban involved seismological data and methods. I have already argued that seismic and other verification measures are good enough to reliably monitor a comprehensive test ban down to explosions of very small size even if the Soviet Union tries its best to cheat. I've also argued that seismological data indicate that the Soviet Union has not cheated on the threshold treaty. I believe that focusing on those two issues displaces attention from several larger issues that deserve more extensive discussion.

Do the advantages of the comprehensive test ban outweigh the possible military disadvantages arising from possible clandestine testing at yields of a fraction of a kiloton?

Two, is the security of the United States or the Soviet Union decreased by a continuation of atomic testing?

And, three, does an adequate infrastructure exist within the U.S. Government to conduct a vigorous and thorough monitoring effort that will be needed under a comprehensive test ban?

Another argument against a comprehensive test ban has been that the Soviet Union could and would conduct very small explosions below the detection threshold of any seismic monitoring stations like those within the Soviet Union.

I've estimated that the identification limit is about 1 kiloton with U.S. stations on Soviet territory. That size of explosion is, of course, much smaller than the yields of weapons deployed on strategic systems today and well below the sizes of weapons that opened the

atomic age in 1945. It is also well below the 5- to 10-kiloton size cited in congressional testimony in 1978 as being a test of military significance.

It is clear that arguments will continue to be put forth that the testing of very tiny weapons could be of significant military advantage, whether that is the case or not. Thus, I believe that a serious alternative to a comprehensive test ban treaty that would accomplish the same things would be a low yield threshold treaty with a limit of about 1 kiloton.

Relatively little attention has been focused on the disadvantages that are likely to follow if the 150-kiloton limit on the testing of weapons is not continued. Both the United States and the Soviet Union have had to conduct their very largest underground tests at very remote sites away from their main testing areas. That is, for the United States, Nevada and for the Soviet Union, central Asia.

Prior to the TTBT the United States conducted its largest tests at a very remote place called Amchitka in the Aleutian Islands, while the Soviet Union detonated its largest tests at its Arctic test site at Novaya Zemlya. The U.S.S.R. has continued to conduct some small tests at that second test site in the Arctic in conformance with the terms of the TTBT. The United States, however, has tested at Nevada after 1976 but not at Amchitka.

The United States could not conduct very large tests in Nevada without incurring damage in Las Vegas, surrounding communities, and possibly in Reno. Thus, in the absence of an agreement between the United States and the Soviet Union not to conduct very large tests, the Soviet Union could resume testing of weapons larger than, say, 1 megaton relatively easily while the United States could not do so very quickly or easily.

In summary, let me state that the threshold and peaceful explosions treaties are verifiable with a high degree of confidence. Both treaties call for extensive verification procedures, including upon ratification the exchange of data that would permit more accurate verification.

There is a growing preponderance of scientific opinion that the Soviet Union has not violated the threshold treaty.

It is in the best interests of the United States that the Soviet Union not test very large weapons. Hence, it is very much in our interests that we ratify both treaties and reenter negotiations toward a comprehensive test ban treaty.

APPENDIX 66

RESPONSES BY LYNN SYKES TO ADDITIONAL QUESTIONS SUBMITTED BY MINORITY MEMBERS OF THE SUBCOMMITTEE ON ARMS CONTROL, INTERNATIONAL SECURITY AND SCIENCE

Question. In regard to Comprehensive Test Ban (CTB) negotiations, Ambassador Stoessel said this before our Subcommittee, "I feel that uncertainties condemning verification technology, plus the Soviet record of violations make it inadvisable to proceed immediately to bilateral—or resumed trilateral with the United Kingdom—negotiations for a CTB with the Soviet Union." Given the record of Soviet non-compliance with arms control agreements, including the ABM agreement, the Soviet invasion Afghanistan, the Soviet shoot-down of the Korean airliner, and the Soviet killing of an American military officer, as well as persisting questions over verification technologies, why should this subcommittee approve H.J. Res. 3, which urges approval of the Threshold Test Ban Treaty (TTB) and the Peaceful Nuclear Explosion Treaty (PNET) and most importantly, instructs the President to immediately begin Comprehensive Test Ban (CTB) negotiations with the Soviets (after those very same CTB negotiations were cutoff with the Soviets by Jimmy Carter)?

Can you comment on these observations?

For what reasons, apart from Afghanistan, did the CTB negotiations break down under Jimmy Carter?

Answer. Uncertainties in verification technology and allegations of Soviet cheating on the Threshold Test Ban Treaty have been cited as important reasons for not continuing negotiations towards a Comprehensive Test Ban Treaty. I have argued in my testimony and prepared statement for the hearings of May 8 that during the last year the scientific community has come much closer to a consensus about the correct methodologies for estimating yields of Soviet explosions using seismological data. I have been part of a committee that has examined the question for the Defense Advance Research Projects Agency (DARPA). That panel and another panel formed by the Air Force Technical Applications Center have reviewed these questions extensively and in recent classified reports recommend the inclusion of yield estimates based on surface waves.

Although I and many others have long advocated the use of surface waves in addition to shorter-period body waves for yield estimation, the United States has relied in the past as it does today solely on body waves. The amplitudes of body waves are now universally acknowledged to vary strongly with the properties of the outer 100 miles beneath various testing areas. The case for Soviet cheating on the Treshold Treaty has evaporated as new techniques of seismic calibration have been tested and used and as new techniques of seismic calibration have been tested and used and as we have learned to calibrate the outer 100 miles of the materials beneath various sites. While by far the majority of scientific opinion indicates that the U.S.S.R. has been in compliance with the Treshold Treaty and has been observing a yield limitation, a small number of persons in DARPA and Los Alamos continue to insist on using old formulas for yield estimation which rely solely no body waves.

In his testimony Dr. Barker mentioned that there is non-seismological evidence for Soviet cheating on the Treshold Treaty. It has long been recognized that seismology provides the most accurate estimates of yield. Dr. Barker has chosen to cite a dubious and uncertain piece of evidence that has received very little discussion and review within the government or through review by external experts.

Question. Ambassador Stoessel, chief negotiator of the TTB and PNE, in testimony before our Subcommittee maintained that "on the technical side, there is continuing controversy regarding our ability to verify with sufficient accuracy the yields of nuclear explosions in the Soviet Union. While experts differ, many maintain that, without direct, on-site inspection, it is impossible to obtain adequate verification, and they hold that this would be the case even with the exchange of data provided for in the TTBT. They note, too, that these data are to be provided from each side's sources, and they claim that—given the record of Soviet violations as likely violations of arms control agreements—this is reason to question the reliability of such data."

Is this data exchange being made as provided by the TTB since both the U.S. and the Soviet Union have agreed to abide by the treaties though they are not ratified?

Has this data exchange procedure been fully resolved?

How can one tell if the data concerning calibration shots was correct?

Some believe it is necessary to obtain independently verified data that allows less ambiguous yield estimates for TTBT verification purposes. One specific U.S. propos-

al is for a direct yield measurement obtained by inserting a cable near the emplacement hole which would directly measure the explosion. In this regard, U.S. personnel would be required at Soviet test sites and Soviets would monitor U.S. tests. Can you comment on such a proposal?

Has the U.S. made any such proposals to the Soviets and if so, what has been the Soviet response. The June 3, 1983, edition of the Baltimore Sun reported that Lynn Sykes, of Columbia University, told the American Geophysical Union that the size of underground nuclear explosions at Soviet test sites could be determined with an uncertainty factor of 15-25% of the force of the blast. Yet many contend that the 150 kt level is difficult to verify, given the problems of Soviet compliance with the TTBT. Can you comment on these observations?

Answer. The accuracy of yield estimates for Soviet explosions is, of course, vital to ascertaining if the Soviet Union has complied with the terms of the Threshold Treaty. Very often general statements are made that yield either can or cannot be determined with sufficient accuracy. I have stated that yields of Soviet tests at their central Asian site (Shagan River), where the Soviets have conducted their largest tests since the TTBT took effect in 1976, can be determined with an accuracy of about 30%.

The upper half of the enclosed figure shows a histogram of numbers of explosions (vertical axis) as a function of their size, i.e., the seismic magnitude, m_b (horizontal axis). The figure shows that Soviet testing practice is to conduct large numbers of tests of a few specific sizes or yields, which are indicated by the sharp peaks in the diagram. If yields were as uncertain as Dr. Kerr and Dr. Baker maintain, those peaks would be much broader and not nearly as sharp as they are in the figure.

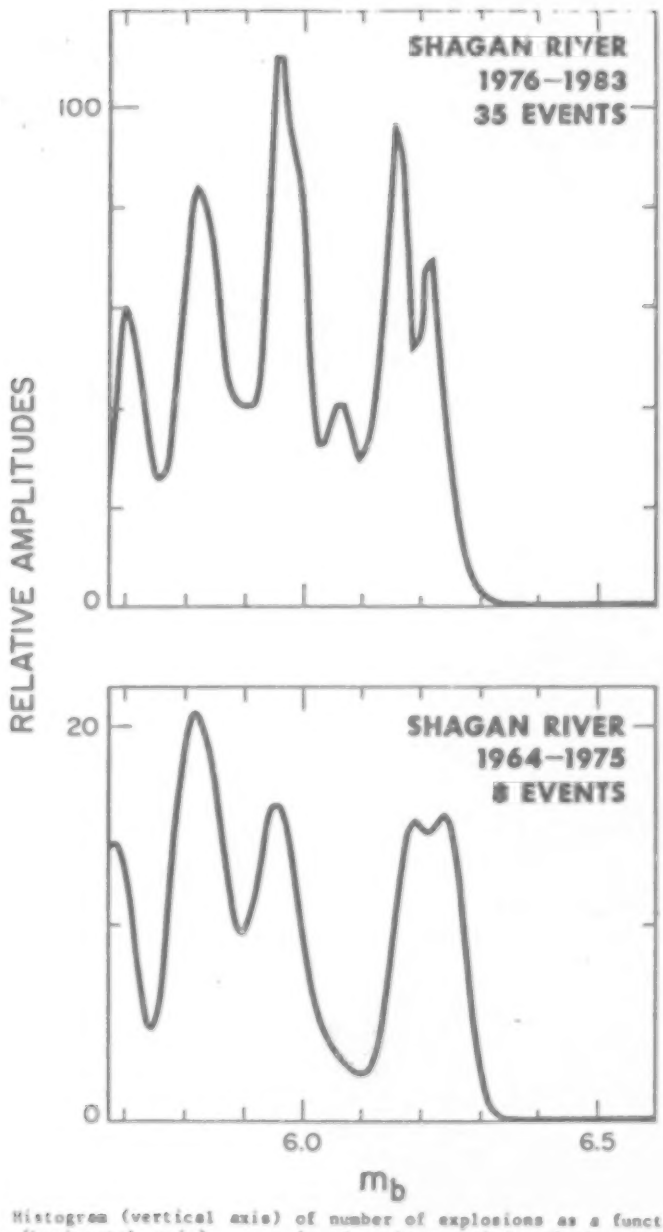


Figure 1. Histogram (vertical axis) of number of explosions as a function of their size (horizontal axis). m_b is the short-period seismic magnitude. Note that Soviet testing practice at the Shagan River testing area in Central Asia is to detonate many explosions of a few specific yields. The narrow width of the peaks indicates that Soviet testing practice at Shagan River, where the largest U.S.S.R. explosions have been detonated since 1976, is indicative of small uncertainty in yield.

In his testimony Dr. Kerr stated that he did not believe a 30% difference in yield, i.e., 195 vs. 150 kilotons, would be militarily significant but that a factor of 2 would be, i.e., a test like 300 kilotons. Let us assume that he is correct, and ask if the Soviet Union were to test an explosion of 300 kilotons, what is the chance that our monitoring systems would report it as being of a certain yield or greater? The 30% uncertainty that I have cited represents one standard deviation. If the yield of the explosion were 300 kilotons, there is an 84% chance that our systems would report it as having a yield greater than 230 kt, a 98% chance that it was of 178 kilotons or greater and a 99.6% chance that they would report it as larger than 150 kilotons.

A factor of two uncertainty has often been cited in conjunction with yield estimates. When one looks closely at reports and articles on the subject, one finds that that factor of two is not associated with one standard deviation but with two standard deviations, i.e., a 95% confidence level. Statistics have often been misused in portraying what is in fact a very high level of confidence as a likely probability. A factor of two associated with two standard deviations corresponds to a 41% variation in yield at one standard deviation. When that is compared with my estimate of 30%, the two estimates of uncertainty do not differ greatly.

Let us again ask the question if the Soviets test an explosion of 300 kilotons, what is the chance that U.S. systems will report the yield as greater than a certain amount if a factor two corresponds to two standard deviations? In that case there is a 84% chance that the yield will be reported as 212 kilotons or greater and a 98% chance that it will be reported as greater than 150 kilotons. In either case we arrive at a high probability that the U.S. systems will calculate a yield well in excess of 150 kilotons.

In the context with which we are dealing, sufficient accuracy, we need to ask what does it take to deter the Soviet Union from testing say 300 kilotons? I conclude that a 84% chance of the explosion being registered by U.S. systems as being at least as large as 212 or 230 kilotons respectively by the above two methods constitutes a sufficient deterent to the U.S.S.R. detonating explosions with yields of military significance in excess of 150 kilotons.

As mentioned in question 2, one specific U.S. proposal is for a direct yield measurement obtained by inserting a cable near the emplacement holes of U.S.S.R. explosions. That method probably would permit more accurate estimates of yield to be made. Nevertheless, we must ask what constitutes sufficient accuracy. During the negotiations for the TTBT and PNET from 1984 to 1986 seismologists informed U.S. officials of expected uncertainties in yields (either without the data package or if we were to assume it was reliable). At that time a factor of two uncertainty was considered politically acceptable by the Nixon and Ford administrations. In fact, estimates of yield have improved since that time.

What has changed since 1976 are demands for greater accuracy. Those demands have rarely been stated in other than vague terms. The question could be put: is an accuracy of 30% (or 41%) at one standard deviation sufficient to deter cheating of possible military significance? Dr. Kerr's statement about 300 vs. 150 kilotons indicates that it is sufficient without asking for additional verification measures or renegotiation of the TIBT.

The U.S. proposal for measurements at Soviet test sites is probably the most intrusive proposal that has been made for renegotiation for the Threshold Treaty. Like Dr. Hannon I think that other less intrusive requests would stand a better chance of being accepted by the U.S.S.R.

Question. Have the Soviets rejected all proposals concerning improved verification for TTBT? Why do you think the Soviets have refused to cooperate in improving upon verification of the TTBT?

While the U.S. is abiding by the 150Kt limit, under the TTB and PNE, The White House, in its arms control compliance reports to the Congress, has revealed U.S. concerns regarding Soviet compliance with the TTBT. The U.S. has judged that while ambiguities in the pattern of Soviet testing and verification continued in 1984, evidence available through the year confirms the finding that the Soviet nuclear testing activities for a number of tests constitute a likely violation of legal obligations under the TTBT, which bans underground nuclear tests with yields exceeding 150 kilotons.

Can you comment on the problems posed by the reported Soviet relations?

Answer. Already answered above.

Question. Verification capabilities assume an extremely important role in maintaining a Threshold Test Ban and Comprehensive Test Ban. On the question of verification, the Carter Administraton asserted that our national verification capabilities in the last twenty years have advanced to the point where we no longer have to

rely on on-site inspection to distinguish between earthquakes and even very small weapon tests.

Do you believe that the U.S. now has the national technical means to enforce a TTB let alone a CTB, without on-site inspections?

What recommendations would you make to improve verification for the TTBT?

How would you construct the verification provisions?

Answer. As stated above I believe the U.S. now has the national technical means to enforce a Threshold Treaty without on-site inspections. In that context I am assuming that on-site inspections would be allowed for peaceful explosions as specified in the Peaceful Explosions Treaty.

Similar reasoning can be applied to ascertaining if data on calibration shots given to us by the Soviet Union are correct. In fact, data on calibration explosions are not as vital now as they were deemed to be during the negotiations for the TTBT in 1974. At that time we did not have a good calibration of the various factors that effect the amplitudes of the short-period seismic waves that were used then (as they are used now) for yield estimates. We now have several seismic methods that give us consistent results on the calibration of short-period waves for the main Soviet test sites. In addition surface wave data and analyses have improved to the point in which they can be used for an accurate and independent calibration of yield.

The Threshold Test Ban Treaty also calls upon ratification for the exchange of geological and geophysical information about test sites. I conclude that those data will allow us to make qualitative improvements in the estimates of yield. As I stated in my testimony, we already have information about the geology of Soviet testing areas and abundant satellite photography of them. Those existing data allow us to make a number of important cross checks on the data package the Soviets would furnish us.

My views are similar to those in the letter sent to the Committee by Dr. Hannon of Lawrence Livermore. The geological and geophysical package is not an all-or-nothing thing that must be either completely accepted without reservation or completely rejected under the notion that none of its components can be checked. I believe reality is somewhere in between. Those aspects of the data package should allow us to make better estimates of the effects of the materials near explosions upon the sizes of seismic waves and hence allow us to calculate yield somewhat better than is now possible.

I recommend that on-site inspections, such as those of the challenge type, be a part of a Comprehensive Test Ban Treaty. Under a CTBT, however, it is more important that we have data from U.S. monitoring stations within the U.S.S.R. as was agreed to in the negotiations from 1977 to 1980. While seismological techniques for identifying underground weapons tests are highly reliable, they will not be 100% foolproof for explosions that are close to the lower limits of U.S. detection and identification systems. On-site inspections of the challenge type provide a means for the United States to demand access to the U.S.S.R. so as to verify if the signals from a small questionable event were those from an underground explosion or those generated by a small earthquake. Seismological identification has improved as much in the last 25 years that we no longer require the larger number of on-site inspections per year that the U.S. stated it did require in 1958 or 1963.

If the United States wishes to improve the verification of the Threshold Treaty we might ask the Soviet Union for various data that would allow us to calibrate the amplitudes of seismic waves in the Soviet Union more accurately. We might ask them, as an act of good faith, to turn over at least a portion of the geological, geophysical and calibration data prior to ratification. Another possibility would be to allow U.S. monitoring stations to operate for a period of time near the boundaries of their testing areas.

Question. Also, according to White House compliance reports, the Soviet Union has been sending radioactive nuclear debris across its borders for years in violation of the Limited Nuclear Ban Treaty. Can you comment on this matter?

Answer. It has been known for many years that both the U.S.S.R. and the United States have violated that item of the Limited Nuclear Ban Treaty of 1963 that prohibits radioactive nuclear debris from drifting across international borders. Neither country has violated the principal element of the 1963 treaty that forbids testing in the atmosphere, space or underwater. It is impossible to carry out large numbers of underground tests, as both the U.S. and the U.S.S.R., do without there being some probability that uncertainties in geology will cause some tests to leak into the atmosphere.

Question. An important assumption underlying the U.S. commitment to a Comprehensive Test Ban (CTB) has been that the CTB would affect stockpile confidence equally in East and West, and therefore not affect the strategic balance.

Can you comment upon this assumption?

What do you believe the Soviet Union would do under a CTB?

What do you believe the U.S. would do under a CTB?

Answer. This item is covered in my written testimony. Dr. Kerr and others have argued that the U.S.S.R. might be able to conduct very small tests that would not be identified under a Comprehensive Treaty that would be of military significance and would allow them to test the confidience of their stockpile. An alternative to a full or comprehensive test ban is a very low-yield threshold treaty, perhaps one with a yield limitation of about 1 kiloton. A low-yield treaty would allow both countries to conduct very small tests. It would not give the Soviet Union a possible asymmetrical advantage if they tested at yields below the identification thresholds of our systems.

Question. Ambassador Stoessel told this Subcommittee that "given the persisting controversy over verification technologies and the evidence of Soviet non-compliance with a number of arms-control agreements, including the TTBT, I conclude that it would be desirable to provide for enhanced verification procedures in the TTBT and PNE agreements before they are ratified by the U.S. Senate.". . . Can comment on Ambassador Stoessel's conclusion?

Answer. Answered under 2.

Question. Is verification the major issue delaying the CTB, or are there other important national security issues involved?

Answer. I have argued in my testimony and elsewhere that verification is not the major issue delaying a Comprehensive Test Ban.

Question. Some scientists and defense experts have argued that a CTB is not in the interest of the United States even if it would be perfectly verifiable, largely because our deterrent, including the defense of our allies, continues to rely on nuclear forces. Why do you believe the U.S. should sign an agreement which would result in the eventual erosion of our only real deterrent against any adversary?

How would the gradual and asymetrical loss of confidence in U.S. nuclear weapons deterrent under a CTB increase the pressure on some of our allies to provide for their own nuclear defense?

Answer. I strongly believe that the United States should only enter into agreements with the U.S.S.R. that are verifiable and equitable and that affect the performance of nuclear weapons of the two countries in a asymmetrical fashion. The wording of the question assumes that a CTBT would result in a gradual and symmetrical loss of confidence in U.S. nuclear weapons. A verifiable low-yield treaty would go far in assuring that any effects on force structure would be symmetrical.

If one is interested in the preservation of MAD, more is involved than the testing of weapons. The trend over the past 20 years since the signing of the Limited Test Ban has been in the direction of increased instability rather than stability. This has occurred as a result of the development of accurate, multiple warhead missiles, greater numbers of weapons that can be carried intercontinental distances and the shorter response times involved. If a full test ban treaty had been signed in 1963 or soon thereafter, I believe the United States and the Soviet Union would be far more secure than they are today. The development of many new weapons systems by both superpowers would have been stopped or greatly curtailed under a Comprehensive Test Ban. In addition, nearly everyone agrees that in 1963 the United States had a vast lead over the Soviet Union in delivery systems and in the number and variety of atomic weapons. At that time we were urged by opponents of a Comprehensive Test Ban to continue the testing of new nuclear weapons in the expectation that that would have a major impact on the strategic balance. In retrospect I think it is clear that the United States missed a great opportunity to freeze in or prolong for many years a commanding lead vis-a-vis the U.S.S.R.

Question. Many continue to support the concept of Mutual Assured Destruction (MAD) while opposing the President's Strategic Defense Initiative (SDI) which could result in Mutual Assumed Survival (MAS). If one is interested in the presevation of MAD, which involves the maintenance and even preservation of nuclear weapons for relative stability, why should we support a CTB which would not allow, for every long, the preservation of nuclear weapon through the primary mechanism of testing?

Answer. None.

Question. In our last hearing on this subject it was pointed out that the U.S. could simply take an old warhead off the shelf and place it on a new weapon system such as the Midgetman ICBM, yet Dr. Barker, in the August, 1983, edition of Physics Today you state that in every case to date, the replacement system (i.e. newer missile) has required a nuclear weapons different from that of the system it replaces. Can you and Dr. Kerr comment further on this matter?

Answer. None.

Question. Our national laboratories, for safety and security related reasons, have been in the process of incorporating insensitive high-explosive mixtures which can survive quite violent impacts in new nuclear weapons systems. Because the weapons with the new insensitive explosives are based on new designs that differ substantially from those using older explosives, testing plays a critical role in the conversion to safer nuclear weapons. How would a comprehensive test ban agreement impede conversion to "safer" nuclear weapons?

Answer. None.

Question. It has been pointed out by some scientists and defense experts that stockpile problems do occur, largely from metallurgical or mechanical problems, or from stricter standards of nuclear safety. How would a CTB impact upon our ability to improve the safety of our warheads and to confound terrorist activity, since newer and safer warheads would require testing?

Answer. None.

Question. In the normal course of events, a large data base is accumulated about nuclear weapons in the stockpile. To what extent would a data base, for the sake of performance and safety, of scheduled new weapons be affected by a comprehensive test ban?

Answer. None.

Question. Have the weapons in the U.S. stockpile been designed deliberately to survive under a prolonged CTB?

If they get sick and need repair, or rebuilding, can this be done with confidence after a long period without testing?

Is testing an essential part of the weapons technology program, or can the weapons technology be maintained by non-nuclear experiments and computer studies?

How does our past experience affect the answer?

Question. To what extent would a CTB complicate the conservation of scientific skills important to national security. (U.S. scientists and laboratories would eventually confine themselves to other tasks but the Soviet government can order scientists around.)

Answer. None.

Question. What position did the National Laboratory Directors take with regard to tests required to give continued assurance of weapon performance during a CTB of unlimited duration?

Answer. None.

Question. Before the CTB negotiations ended several years ago, the U.S., Great Britain and the U.S.S.R. agreed on the use of unmanned seismic stations which could be placed in a country to enforce a CTB. Can you comment on the problems, both positively and negatively, of the use of such seismic stations?

Answer. U.S. seismic listening posts in the Soviet Union would allow the United States to verify a Comprehensive Test Ban reliably down to explosions of smaller size than would be possible with external stations alone. Hence, I believe that the United States should continue to place great emphasis in negotiations on U.S. seismic stations within the U.S.S.R. Over the years the U.S.S.R. has shown greater flexibility in permitting seismic stations on its territory than they have with on-site inspections. I see no necessity for all U.S. stations to be either manned or unmanned. Unmanned systems that are tamper-proof and which transmit their data by satellite have been developed and tested.

Question. Was there an impasse involving the United Kingdom on the locations of so-called "black boxes" for seismic monitoring of a CTB?

Answer. I was not involved in the negotiations towards a CBTB in which this item was discussed.

Question. What is the level of yield at which we can now detect and identify nuclear tests and with what confidence?

Answer. I argue in my written testimony that with U.S. monitoring posts within the Soviet Union that a CTBT could be monitored with high reliability for yields of about 1 kiloton.

In the fall of 1983 an informal conference was held on the problem of verifying a CTBT or a low-yield threshold treaty. At the end the convenor asked the participants, who came from the Department of Defense, universities, the U.S. Geological Survey and the Lawrence Livermore Lab, what would be the lower limit of identification of U.S.S.R. explosions assuming the United States had a network of listening posts within the Soviet Union. Those who were questioned held a wide variety of beliefs about the desirability of a Comprehensive Test Ban Treaty. Nevertheless, the answers that they gave ranged from 1 to 5 kilotons.

At a symposium on verifying nuclear tests for the American Geophysical Union in the spring of 1983 a scientist from the Defense Advanced Research Projects

Agency, Dr. Thomas Bache, stated that the U.S.S.R. would be able to hide explosions of tens of kilotons even if the United States had large numbers of stations within the U.S.S.R. Dr. Hannon of the Lawrence Livermore Lab, another one of the speakers, was asked to comment upon that statement in view of his extensive calculations on network capabilities. He replied that there was no subsidence to the allegation that the Soviet Union could hide tens of kilotons clandestinely with U.S. monitoring posts in the U.S.S.R. I am not aware that Bache or other officials from DARPA, have published in either the open or classified literature any data or calculations to support that statement.

On page 12 of his written testimony Dr. Kerr makes a similar statement that tests of a few tens of kilotons could be conducted in violation of a total testing ban. It is widely recognized in the seismological community that the Los Alamos Lab that Dr. Kerr heads, while it is preeminent in the design of nuclear weapons, has very little capability in the area of seismological verification of a CTBT or TTBT. I am not aware that anyone from Los Alamos has published data that would argue the case that tens of kilotons can, in fact, be concealed under a CTBT.

The Lawrence Livermore Lab has a much greater number of seismological experts working on nuclear test detection and verification than does Los Alamos (by about a factor of 10 or 20). This is one of the reasons that I think that the positions taken by Dr. Kerr on the verification of the TTBT and a CTBT are in conflict with the views of the much larger and scientifically stronger seismological community at Livermore. I do not think that Dr. Kerr's views on those two questions stand serious scientific scrutiny.

Dr. Kerr stated that high-frequency seismology may hold promise for increasing the sensitivity of detection systems for decoupled tests but that this remains to be demonstrated. That capability is, in fact, greater than Dr. Kerr suggests. The one nuclear explosion that the United States detonated to test the decoupling theory showed that the amount of decoupling or muffling was not as great at high frequency (30 Hertz) as it was at those frequencies that are normally used to intercontinental monitoring. Those results were published by Drs. Healy, King and O'Neill of the U.S. Geological Survey in 1971. While the amount of muffling at high frequencies is still a significant factor, that test demonstrated that the effect at high frequencies, as predicted theoretically, is only 25% of that for waves detected at intercontinental distances. Norwegian seismologists using data from the NORSAR seismic array have shown that high-frequency waves are commonly detected for explosion of 1 kiloton or smaller for several parts of the U.S.S.R. Those effects were seen at a distance of several thousand miles from the explosions. While more work obviously remains to be done to quantify the capabilities of high-frequency monitoring, those data sets and theory are strongly indicative that high-frequency waves are a way of better detecting explosions detonated in large cavities.

Question. The September 8, 1983, edition of The Washington Post, reported that the Arms Control and Disarmament Agency, in a answer to written questions from the House Appropriations Committee, stated that a test ban could not itself end the threat posed by nuclear weapons, since it does not deal directly with the kinds, numbers, or deployment of nuclear forces. Can you comment on this observation?

Question. President Carter, in a September 29, 1977, news conference said "I recognize that progress on SALT leads to further progress on a comprehensive test ban." Do you believe that test bans and nuclear arms reductions are interdependent?

Do you believe that arms reductions in Geneva can lead to further progress on a comprehensive test ban?

Do you believe that test restrictions should be subordinate to progress on nuclear arms reductions?

Questions. Some believe that stopping nuclear testing will somehow reduce the possibilty of nuclear war?

Can you comment on this observation?

Answer. Here, I believe, is an area in which we are in agreement: that a test ban by itself would not end the threat posed by nuclear weapons. While I think that a Comprehensive Test Ban or a low-yield threshold treaty would be a very important arms control measure, it should not be thought that it alone would either end the arms race, reduce entirely the threat of nuclear weapons or usher in an era of disarmament. It would be a more modest measure. Nevertheless, if a CTBT were coupled with a ban on missile testing, cuts in offensive systems and limitations on weapons in space, the net effect of those agreements would have a major impact on the arms race. Of course, a CTBT by itself would not reduce the stockpiles of existing weapons.

Question. Mr. Barker, some argue if the U.S. and Soviet Union ceased testing, it would signal to other countries that we are serious about ending the arms race and nuclear proliferation. Yet you state in the August, 1983, edition of Physics Today that U.S. confidence in its nuclear detterent, which could be affected by a CTB, would also have international implications. Can you comment on the impact that a CTB may have on our friends and allies?

Answer. None.

Question. Dr. Sykes, in a statement to this Committee, said that a CTB could be verified down to one kiloton. Moreover, Dr. Sykes maintains that politics—not technology—prevents us from concluding a comprehensive test ban.

Can you comment on this observation?

Answer. None.

Question. Dr. Sykes, in an article entitled the "Verification of a Comprehensive Nuclear Test Ban" which appeared in the October, 1982, edition of Scientific American, you stated that we are certain that the state of knowledge of seismology and the techniques for monitoring seismic waves are sufficient to ensure that a feasible seismic network could soon detect a clandestine underground testing program involving explosions as small as one kiloton. What do you mean by the words "feasible" and "could soon detect"?

Can the other witnesses comment upon whether a test ban can be detected down to one kiloton?

Answer. None.

Question. This Subcommittee has received testimony from Dr. Willard J. Hannon, Program Manager of the Seismic Monitoring Research Program at Lawrence Livermore National Laboratory, who concluded that the current assessments of the relationships among yield seismic magnitude and the pattern of Soviet testing at their Shagan River test site indicate that the Soviets are observing a yield limit in their testing program which is consistent with TTBT compliance. Yet, in the January, 1985, edition of Science magazine, Dr. Hannon states that the lack of in-country Soviet explosion data seriously limits U.S. confidence in its ability to identify smally seismic events and that the size of the Soviet Union and operational and security considerations provide many possible sites for clandestine testing. Moreover, he states that seismic verification of a CTB will not ensure identification of all underground explosions. Can you comment on these observations?

Answer. None.

NUCLEAR TESTING ISSUES

WEDNESDAY, APRIL 30, 1986

U.S. SENATE,
COMMITTEE ON ARMED SERVICES,
Washington, DC.

The committee met in open session, pursuant to notice, at 11:08 a.m., in room SR-232A, Russell Senate Office Building, Senator John W. Warner, presiding.

Present: Senators Warner, Thurmond, Nunn, Exon, Levin, Kennedy, and Dixon.

Staff present: Arnold L. Punaro, staff director for the minority; Robert G. Bell, Robert F. Bott, Douglas R. Graham, and David S. Lyles, professional staff members; and Karen A. Love, staff assistant.

Also present: James M. Bodner, assistant to Senator Cohen; Janne E. Nolan, assistant to Senator Hart; Jeffrey B. Subko, assistant to Senator Exon; John B. Keeley, assistant to Senator Levin; and Thomas K. Longstreth, assistant to Senator Kennedy.

OPENING STATEMENT BY SENATOR JOHN W. WARNER, PRESIDING

Senator WARNER. The committee will convene in open session this morning to receive testimony on nuclear testing issues. In view of the demands of the Senate schedule, and the briefing for members on the nuclear accident in the Soviet Union, we were unable to complete this hearing yesterday afternoon.

The Chair very much appreciates the flexibility of committee members, and in particular of our witnesses, in agreeing to resume this hearing this morning.

Our witness this morning is Dr. Alton Frye, the Washington Director of the Council on Foreign Relations.

The Chair is sorry that Dr. Hans Bethe is unable to be with us, but his schedule would not permit it.

In addition, Dr. Donald Kerr, the senior vice president of EG&G, Inc., and the former director of the Los Alamos National Laboratory, was scheduled to testify yesterday but was unable to do so because we ran out of time. Today he is testifying on the House side and we are hopeful he will be able to join us later in the day. However, it is the Chair's intention to keep the record open to receive Dr. Kerr's testimony.

It is also the Chair's intent to keep the hearing record open until the close of business today to permit members to submit questions for those witnesses.

At this time, I would like to insert a document in the record that was prepared by the Los Alamos National Laboratory. This document describes in some detail the CORRTEX technology for verifying underground nuclear tests. CORRTEX is the technology that President Reagan has proposed to the Soviet Union as his preferred solution to the verification problems associated with the Threshold Test Ban Treaty.

[The CORRTEX document follows:]

U.S. Department of Energy
Nevada Operations Office

Los Alamos
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

CORRTEX

A new measuring system, called CORRTEX, can improve U.S. confidence in treaty compliance and possibly ease the way to further cooperation with the Soviet Union on other arms control issues. The lack of effective methods for verifying the size of underground nuclear weapon tests has proved to be a stumbling block for ratification of two major, closely linked nuclear test agreements, the Threshold Test Ban Treaty (TTBT) and the Peaceful Nuclear Explosions Treaty (PNET).

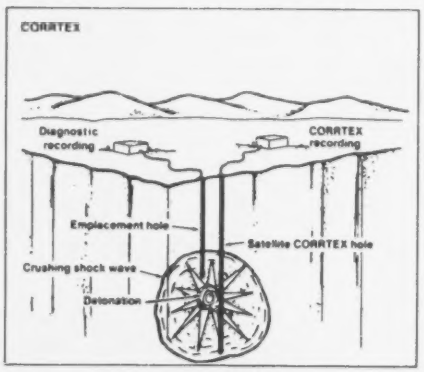
In March 1986, President Reagan proposed using CORRTEX to improve verification and ensure compliance with the TTBT, signed in 1974. This treaty limits explosive yields of underground nuclear weapon tests to not more than 150 kilotons. To date, verification of weapon testing limits has been based on remote monitoring, using a worldwide network of seismic stations that infer yields from the size of explosion-generated signals. The seismic procedure involves several assumptions about the local geology of test locations and about the modes by which signals travel to the seismic stations. An opportunity for relatively large inaccuracies in the yield determination is one result of these assumptions.

CORRTEX (an acronym for Continuous Reflectometry for Radius versus Time Experiments) is a fast, more accurate method for measuring yields of underground nuclear explosions and for ensuring compliance with the treaties. CORRTEX-type measurements have long been accepted as the technology of choice for verification of the PNET. But of foremost importance to the TTBT, CORRTEX also allows these measurements without revealing key weapon design information.

The CORRTEX system consists of a suitcase-size electronic unit, coaxial cables, and a microcomputer for data reduction. The electronics are so compact and rugged that they can be checked as ordinary airplane baggage and function properly after the abuses of travel. All equipment for power, recording, and data reduction can easily fit into a small trailer.

In use, the battery-powered electronic units remain above ground and can be remotely controlled. One or more coaxial electric cables attached to the units are inserted into holes extending from ground level to a point near the nuclear explosive. Repetitive electrical pulses are sent down the cable at intervals of 10 to 90 millionths of a second. The pulses reflect from the end of the cable and return to their source. Each electronic unit can alternately pulse two sensing cables.

When the nuclear device explodes, the shock wave travels outward and progressively crushes the cable, producing a fast-moving short circuit. Electrical pulses sent from the surface down the cable encounter the short circuit and are reflected to the electronic unit. The



CORRTEX cables attached to an electronic unit are placed in separately drilled holes parallel to the hole containing the nuclear device and diagnostic equipment. When the detonation occurs, the resulting shock wave moves outward, crushing and short-circuiting the cables. The electronic unit on the surface records the progressive movement of the shock wave as a function of time. From these data, the microcomputer can calculate the yield of the explosion.

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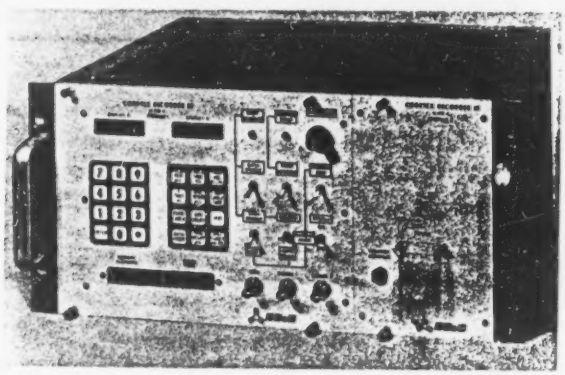
time required for the pulses to complete the round trip steadily diminishes and reveals the length of the cable—and therefore the location of the shock wave—as a function of time. More than 4,000 recorded data points cover the growth of the shock wave. A portable microcomputer then processes these data, to give the speed with which the electrical cable is shortened, and determines the yield of the explosion. Large explosions produce shock waves that travel faster than do those from small explosions. The microcomputer presents the recorded data in several forms, including graphics.

CORRTEX is based on ideas that go back to the early days of atmospheric testing when scientists determined the size of a nuclear explosion by measuring the supersonic growth of the shock wave in air (the fireball). With CORRTEX, scientists now measure the velocity of the supersonic shock wave in earth and determine the size of the underground explosion. Los Alamos National Laboratory, with the engineering support of EG&G, Inc., began development of CORRTEX as a verification tool for the PNET, signed in 1976. The PNET limits to 150 kilotons the yield of each nuclear explosion detonated for peaceful purposes, such as excavation, stimulation of fossil fuel reservoirs, or creation of underground cavities. Los Alamos now routinely uses CORRTEX to measure nuclear test yields at the Nevada Test Site.

Data from these nuclear tests at the Nevada Test Site indicate that, for tests larger than several tens of kilotons, CORRTEX is accurate to within 30% or better of the more direct and "standard" radiochemical yield measurements. This finding is based on many tests with the sensing cables both in the nuclear device emplacement holes and in nearby and parallel satellite holes. The accuracy of CORRTEX is known to be essentially independent of the surrounding geology, provided the measurement is performed in the "strong shock" region closest to the nuclear explosion. At greater distances from the explosion, the geology becomes more important. Placing the CORRTEX cables in a parallel satellite hole a few tens of feet from the emplacement hole appears best for ensuring that a test does not exceed 150 kilotons, while eliminating the opportunity to sense weapon design and diagnostic information.

The advantages of CORRTEX are many. CORRTEX is compact, rugged, simple in operation, fast, and the most accurate of the noninvasive techniques for measuring the yield of underground nuclear explosions.



The CORRTEX electronic unit is a rugged, suitcase-size instrument that can collect and store 4,000 data points per underground explosion.

Senator WARNER. Senator Exon.

Senator EXON. I have no opening statement, Mr. Chairman. Thank you.

Senator WARNER. I will insert Senator Kennedy's opening statement for the record.

SUPPLEMENTAL STATEMENT BY SENATOR EDWARD M. KENNEDY

Yesterday we heard testimony from administration spokesmen in which they stated that, even if a comprehensive test ban could be adequately verified, the administration would oppose such an agreement. This policy is a significant and disturbing departure from the policies of every administration since Eisenhower—Republican and Democratic alike. It is also flatly inconsistent with our obligations under the Limited Test Ban Treaty of 1963 and the Non-Proliferation Treaty of 1968 to pursue such a comprehensive ban.

The views of both the House and the Senate are clear on this issue. By overwhelming votes, the Members of Congress have called upon this administration to at least begin negotiations aimed at achieving a comprehensive test ban and to seek immediate ratification of the TTBT and PNET.

But the administration has taken the extraordinary position that so long as the United States relies on nuclear weapons as a deterrent, it must continue to test nuclear warheads. I find this to be irresponsible and indefensible.

Senator WARNER. Dr. Frye.

STATEMENT OF DR. ALTON FRYE, WASHINGTON DIRECTOR OF COUNCIL ON FOREIGN RELATIONS

Dr. FRYE. Thank you very much, Mr. Chairman.

I welcome the opportunity to present some views for the committee's consideration.

The relationship of nuclear testing to the security of the American people has perplexed us for three decades and more. It deserves the continuing scrutiny you are now giving to it. I would like to make clear at the outset that the arguments I am going to offer are based on a fundamental political premise.

It is my view, having had the privilege of working with Members of this body over many years on many of these issues, that we have to understand the simple truth: We are not likely to reach common ground with the Soviets until we find common ground for Americans. That premise is one that I think holds for many issues, but especially on divisive, controversial questions such as the one of nuclear testing.

We are not going to find common ground for Americans unless we manage greater civility in our debates about matters than sometimes occurs. We have to recongize that each of us as a citizen must respect our fellow citizens' rights to differ honestly about these issues.

I state that simple premise because I will differ quite forthrightly with a number of views that were set forth yesterday by friends of mine who were the administration witnesses. The Senate is a shrine with respect to differences of opinion and I hope to apply its standards in the testimony I offer.

Let me step back briefly and frame what I think is an agreed, but sometimes implicit understanding of what we are about when we have Senate deliberations on issues like nuclear testing. The choice for the Senate and for the country is a choice among risks. There are risks with nuclear testing and there are risks without nuclear testing.

The key question is to make that choice with a full appreciation of the context in which it is embedded. I believe that while the context presented by administration witnesses yesterday is quite understandable, it is misleading in some important respects.

There are some issues which were not adequately addressed which I hope I can put forward in a brief statement this morning. The debate over nuclear test restraints has been chronic and divisive. What is noteworthy in 1986 is how drastically the context of that debate has shifted.

When some of us in this group first worked with the bipartisan Senate coalition that promoted the Limited Test Ban Treaty of 1963, the issue was verification. Could we tell if the Soviets were cheating by testing clandestinely?

Improvements in seismic technology have virtually eliminated that concern and more forthcoming Soviet positions regarding onsite inspections and other cooperative agreements have eroded the weight of contentions that a comprehensive test ban would be unverifiable.

When we worked on Limited Test Ban Treaty, I was a young figure at the Rand Corp. and I was persuaded we could not monitor underground nuclear tests satisfactorily.

I believe the testimony you heard yesterday does not convey the current consensus within the scientific and technical community. The improvements have been so substantial that there is a wide and growing consensus that even at very low levels of tests it will be possible to monitor the kinds of activities associated with nuclear programs.

I would cite, for example, something that Dr. Barker referred to briefly, the implications of the new Norwegian array for detecting test activity in the Soviet Union. The Norwegians, who have worked with us on that array, have gained increasing confidence that they can detect Soviet test activity to very low levels.

For that reason, those same Norwegian allies of ours are pressing emphatically for rapid early movement toward a comprehensive nuclear test ban.

As evidence in addition to that, I would suggest that a recent study concluded by a European panel dealing with nonproliferation carries the message that is the consensus message within the international community.

Basically, they have taken the position in this report just published by the Council on Foreign Relations and the Centre for European Policy Studies, a report based on 3 years of deliberation and research by a very distinguished international panel of Europeans, they have taken the view that a comprehensive test ban would in fact be both achievable and extremely important for maintaining the barrier against nonproliferation.

I think it would be important for the committee not to take one man's view of this, but perhaps to inquire of the National Academy of Sciences for more detached and rounded views of the verification possibilities as they now exist.

I think, for example, in a study by the National Academy's Committee on International Security and Arms Control, which includes a number of very well known figures to this committee—former Air Force Chief of Staff, General Lew Allen; Richard Muller from

the Lawrence Livermore Laboratory; Jack Ruina from MIT; Charles Townes from Berkeley--you will find in this study recently published by them on nuclear arms control a very thorough assessment of the nuclear testing issue including quite a balanced portrayal of the degree of improvement in seismic detection and monitoring.

There is also in connection with this a myth that crept into the testimony yesterday which I think we should clear up. The suggestion was made that, during the 1958 to 1961 period, our laboratories in a no-test environment suffered decimating losses, that their capability declined sharply.

I think that is not reflected in the actual test programs of the two sides. I was here in the fall of 1961 when the Soviets violated the longstanding moratorium on testing. The outrage in the Senate was justifiable in every degree. There was a concern that we beef up our laboratory capabilities and make sure that we not lack the capability to test as necessary in the future.

But even before we beefed up those laboratories, the fact is in the 15 months following the break of the moratorium, from late 1961 through the end of 1962, the Soviet Union conducted something more than 90 nuclear tests. The United States conducted something more than 100. We did not lack the capability. We more than matched the Soviets even in the aftermath of that moratorium.

I think it is important for the committee to realize the strength of our institutional base.

There is one thing that I did not hear in the testimony yesterday for which I am frankly grateful. It is a quite bizarre argument which has crept into the debate in recent months suggesting that a test ban would in fact be harmful to the nonproliferation effort.

That is a line of argument which is so completely out of keeping with the powerful international consensus on that matter that I find it hardly worth extensive discussion. But to the extent that the argument has been made, let me address it briefly.

It is speculated by some that a comprehensive test ban would harm the cause of nonproliferation by reducing confidence in U.S. nuclear capabilities. Some opponents of the test ban say it might encourage other states to acquire their own nuclear weapons. That is a mighty big "might."

To the extent that other states depend on the U.S. nuclear guarantee, we need to frame the question very precisely. How likely is it that such a state would prefer to trade reliance on the thousands of advanced nuclear weapons deployed by the United States on the basis of more than 800 tests over a period of 41 years? How likely would they trade reliance on that for a minuscule number of untested weapons of their own?

I believe the question answers itself. Certainly pressure in the international community for a comprehensive test ban is consistent. It belies the implication that other states secretly hope that the United States will hold out against the CTB.

I remind you that in December 1982 the United States found itself alone, literally a single vote against more than 100 in a United Nations call for resumption of negotiations on a CTB. Last fall the final declaration of the Third Nonproliferation Treaty

Review Conference specifically recalled the obligation of the United States and the Soviet Union "to continue negotiations to achieve the discontinuance of all test explosions of nuclear weapons for all time."

That commitment is expressed in treaty form by both the United States and the Soviet Union in their adherence to the Limited Test Ban Treaty of 1963 and the Nonproliferation Treaty.

The declaration of the NPT Review Conference recited a litany of inadequate efforts by the superpowers to meet their obligations to control the nuclear arms race. The implication was that the obligation of states which voluntarily gave up the option to acquire nuclear weapons might not persist if the superpowers continue to test and build the weapons they pledged to control as part of the nonproliferation bargain.

That is also the message of the so-called five-continent initiative involving such important nonnuclear weapon states as India, Argentina, and Sweden. Whatever speculations one may hear about a CTB potentially encouraging proliferation, the world consensus flatly contradicts them.

A test ban is seen as essential to the long-term viability of the barriers against nuclear proliferation. No serious analyst of American security interests can doubt that those barriers are vital.

There is a second peculiar argument that crept into this debate and it did show up yesterday. I feel obliged to comment on it.

Because the average size of U.S. weapons has come down in recent years, some assert that testing is necessary to shrink nuclear weapons. Now, megatonnage has indeed diminished in the U.S. arsenal, but that was an incidential byproduct of the quest for more efficient and capable systems.

Furthermore, the suggestion that the trend has amounted to a build-down in U.S. capabilities is totally misleading. In the weapons of greatest potency, the number of independently targeted warheads on ballistic missiles, the United States has increased that number fourfold, from under 2,000 to almost 8,000 since 1970.

Similarly, the dramatic surge in Soviet ballistic missile warheads has brought them to parity in that category in that period.

May I suggest that the committee would be well advised to request from the administration a list detailing the exact types and numbers of weapons which have been removed from the U.S. arsenal. I believe you will find that they consist largely of nuclear warheads associated with air defense systems and other weapons we were deciding to phase out anyway.

They have very little relevance to the strategic offensive balance which is the center of our competition with the Soviets. I think we should dispose of this suggestion that there have been meaningful quantitative reductions in strategic offenses by getting a detailed description of the exact weapons which came out of our inventory in that period.

It is that vast expansion in the most advanced weapons that is the principal result of continued testing during recent years. I leave it to members of the committee to reflect then on the question whether the United States would be more secure today if the test ban 20-years ago had reinforced the quantitative limits of the

SALT I agreement to hold both nations' ballistic missile forces closer to 2,000 warheads than to 10,000.

That is rough contrast between the late 1960's and the current situation.

Now, from these observations it will be apparent that I believe the arguments for a CTB have gained strength. The arguments have changed my own position as I have made clear. Without rehearing all the objections to such a ban, let me state simply that I have examined them and do not find them on balance compelling.

In particular, there is a variety of measures that should suffice to maintain confidence in the operability and reliability of the stockpile, especially when that becomes the paramount test and the insistence on continuous design innovation is suppresed.

I recall for you Dr. Bethe's example yesterday of the way in which reliability could be maintained in the stockpile. I also mention again his reference to the views of Dr. Bradbury and Dr. Mark, both of whom, with long experience in the nuclear laboratories, concluded that confidence could be maintained adequately by a variety of measures.

It does seem to me opinion has shifted on this matter and we should not assume that we are faced with declining reliability as a paramount problem in the aftermath of a test ban.

Now, having said all that, I do not come to recommend that you focus your attention on a comprenhensive test ban. I have a larger mission here today than merely conveying a judgment that a CTB is feasible, verifiable, and worthwhile.

The fact, is, as we saw yesterday, that those who are shaping U.S. policy do not share that opinion. For that reason a comprensive test ban is not presently achievable. There is no realistic prospect that the administration will pursue a comprehensive test ban. Thus the practical question for those who are dedicated to forging a bipartisan coalition on these matters is far more difficult.

Are we condemned to a perpetual cleavage on the nuclear testing issue or can one define a middle ground that meets the principal objectives of those on both sides of the dispute?

I believe there is a sound compromise to which we should all repair. That compromise will build upon the prior action by both the House and the Senate in calling for early ratification of the long-stalled Threshold Test Ban Treaty and Peaceful Nuclear Explosion Treaty. The plan would involve three elements.

First, the United States and the Soviet Union, together with other nuclear weapon states, if possible, would each undertake to conduct no more than five nuclear tests per year. Such a quota would be more than ample to maintain confidence in existing weapons and would even permit some development work, albeit at a reduced pace.

But it would sharply curtail the projected rate of testing. Four years or more would be required to complete tests that might now be run in a single year. Thus, it would depend very much on the character of tests we chose to make, but it would respond credibly to the demands of other parties to the NPT that we begin to make progress toward containing nuclear testing.

Most important in terms of the coalition which I hope we can frame, a quota ban of this nature would meet the administration's

stated requirement for some testing to assure stockpile reliability. That central argument against a CTB has no standing as an objection to a quota on tests.

Second, the threshold for tests, now 150 kilotons, would be lowered in steps over a 5-year period. The sequence might well be one of annual cuts to 75 kilotons, 50 kilotons, 25 kilotons, 15 kilotons, ending at a 10-kiloton limit in the fifth year.

I cite the 10-kiloton limit as a target while pointing out to you that it is my understanding one of our most distinguished nuclear scientists has recently suggested we could comfortably move to a 10-kiloton threshold.

Former Secretary of Defense Harold Brown reportedly referred to a possible 10-kiloton threshold as achievable on the current technology base in remarks within the past few weeks.

Reductions to lower levels could eventually occur after the 5-year proposal. They would remain negotiable. In theory, you could reach CTB by gradual reduction of the threshold toward zero.

The important point is that we would have started a 5-year process in which we could do a third thing. That is the third element of the proposal I submit to you. Coupled with a numerical quota on tests and a declining threshold, the United States should propose a 5-year verification experiment to confirm our ability to enforce a comprehensive ban.

General Secretary Gorbachev has now spoken a good deal about his willingness to undertake far-reaching arrangements to ensure compliance, including onsite inspections. We should make this a put-up or shut-up proposition. He has offered it in the context of a comprehensive test ban.

We say an eventual comprehensive ban is still our own objective. Let us make it clear we want to prepare for a serious consideration of that possibility by exercising the verification capability.

Mr. Gorbachev should be persuaded that confidence in any eventual comprehensive ban would be greatly enhanced by installing and demonstrating verification systems during a period in which a limited number of tests are actually in progress.

We will have much more confidence in the capacity of our combined technical capabilities for seismic and related detection in conjunction with our political capabilities to negotiate onsite inspection methods. We will have much more confidence if we can try them out during a period when some tests are in fact taking place.

In conjunction with the threshold treaty ratification and related actions, the parties would be exchanging important geological data and calibration information that should do a great deal to eliminate lingering concerns about possible cheating or deceptive test programs.

A 5-year plan of this nature to refine cooperative verification measures would also testify to the superpowers' good faith in attempting to meet their obligations under the 1963 treaty and the Nonproliferation Treaty.

Let me stress that the importance of the verification experiment goes far beyond the issue of nuclear testing. If we are ever going to achieve the ambitious force reductions both Moscow and Washing-

ton now advocate, it is imperative that the two sides have available tested and accepted methods for monitoring compliance.

The exercise of cooperative arrangements for test verification during this 5-year period could contribute data and procedures for the larger process on which the President has properly focused so much attention.

For those who favor an immediate CTB, this proposal will seem inadequate. It lays groundwork on which a later decision could establish a comprehensive prohibition.

Those who demand all or nothing should recall that the campaign for a comprehensive test ban over three decades has so far produced—nothing. An incremental approach of the sort sketched surely has promise for attracting the support of men and women of good will, whether proponents or opponents of CTB, and unless we can rally that majority of patriots, the prospects are for a festering and debilitating dispute that will in no way serve the Nation.

We have reached a moment, members of the committee, when new initiatives are needed to revive the faltering dialog that opened with President Reagan's reelection and Secretary Gorbachev's arrival in office.

More than anything, the quota test proposals outlined here could produce an early success that could pave the way for larger achievements and help create the affirmative political climate without which little may be accomplished.

Mr. Reagan now enters his final 1,000 days as President with the Soviet-American relationship tangled in difficult knots and the arms control process rather thoroughly stymied. The Senate would serve him and the Nation well by injecting new ideas and fresh momentum toward the worthy goal he set in his first term: Reversing the trend toward ever greater nuclear arsenals.

Unless we reverse that trend, the projections are that we will face between 15,000 and 20,000 Soviet strategic offensive warheads in the course of the 1990's with a matching deployment in the American strategic arsenal. The counsel of this committee on the nuclear test dilemma could prove historic in helping to break that cycle.

I hope you will find those suggestions worth considering. I will be honored to reflect on any issues you wish to raise.

[The prepared statement of Dr. Frye follows:]

PREPARED STATEMENT OF ALTON FRYE

Mr. Chairman, I welcome this opportunity to present views to the Committee. The relationship of nuclear testing to the national security of the American people has perplexed our policy for three decades. It deserves the continuing scrutiny you are giving it.

The arguments I offer for your consideration proceed from a basic premise, one rooted in the conviction that our national security policy demands a durable bipartisan consensus. On the issue of nuclear testing, as on many other controversies over strategic policy and arms control, a simple truth governs: we are not likely to find common ground with the Soviets until we find common ground for Americans. And we will find no common ground for Americans unless we nourish greater civility in our public debates, recognizing that citizens must respect each other's right to differ honestly about such complex issues. The Senate enshrines that insight; I intend to apply it in this testimony.

The debate over nuclear test restraints has been a chronic and divisive one. What is noteworthy in 1986, however, is how drastically the content of that debate has shifted. When some of us in this room first worked with the bipartisan Senate coali-

tion that promoted the Limited Test Ban Treaty of 1963, the issue was verification: Could we tell if the Soviets were cheating by testing clandestinely? Improvements in seismic technology have virtually eliminated that concern and more forthcoming Soviet positions regarding on-site inspections and other cooperative arrangements have eroded the weight of contentions that a comprehensive test ban would be unverifiable.

As evidence on this point, let me mention the work of two panels, one European, one American, dealing with New Approaches to Non-Proliferation. Chaired by Johan Holst of Norway and Gerard Smith of the United States, the panels enlisted diverse and experienced membership to conduct separate but parallel studies over the last three years. Their reports have just been published by the Council on Foreign Relations and the Centre for European Policy Studies in Brussels.

Not every member of these panels supported a Comprehensive Test Ban Treaty, but most saw a CTBT as an extremely important reinforcement of the still-fragile non-proliferation regime. More notable perhaps was the fact that there was virtually no dispute among the panelists that verification capabilities were not sufficient to monitor a CTBT. Indeed, our Norwegian colleagues have gained considerable experience in monitoring undergound nuclear tests; they and other Europeans have grown more confident in demanding movement toward a CTBT. In the European panel's language, "A CTBT would contribute significantly to the stabilization of the non-proliferation regime." The panel was the first independent, multi-national effort of its kind and it conveyed profound concern that the intensification of the Soviet-American nuclear competition was undermining the legitimacy of the non-proliferation regime.

With the collapse of credible verification objections to a CTBT, there has been a scramble for new rationales to oppose further restraints on nuclear tests. That is always a telltale sign. When debaters strain to shore up old positions by inventing fresh rationalizations, one is well-advised to greet them with heightened skepticism. Two arguments recently adduced are especially perverse.

First, it is speculated that a CTBT would actually harm the cause of non-proliferation; by allegedly reducing confidence in U.S. nuclear capabilities, some opponents of a test ban say it might encourage other states to acquire their own nuclear weapons. That is a mighty big "might".

To the extent that other states depend on the U.S. nuclear guarantee, one needs to frame the question very precisely: How likely is it that such a state would prefer to trade reliance on the thousands of advanced nuclear weapons deployed by the United States on the basis of more than 800 tests over forty-one years for a minuscule number of untested weapons of its own?

Certainly the pressure of the international community for a CTBT is consistent. It belies the implication that other states secretly hope the United States will hold out against a comprehensive test ban. In December 1982 the United States found itself alone, literally a single vote against more than a hundred in a United Nations call for resumption of substantive negotiations on a CTBT.

The Final Declaration of the Third Non-Proliferation Treaty Review Conference in September 1985 specifically recalled the obligation of the United States and the Soviet Union to "continue negotiations to achieve the discontinuance of all test explosions of nuclear weapons for all time"—a commitment expressed by us both in adhering to the Limited Test Ban Treaty and the NPT. That Declaration recited a litany of inadequate efforts by the superpowers to meet their obligations to cease the nuclear arms race. The implication was that the obligation of states which voluntarily gave up the option to acquire nuclear weapons might not persist if the superpowers continue to test and build the weapons they pledged to control as part of the NPT bargain. That is also the message of the so-called "Five-continent Initiative," involving such important non-nuclear weapons states as India, Argentina, and Sweden. Whatever speculation one may hear about a CTBT potentially encouraging proliferation, the world consensus flatly contradicts it: a test ban is seen as essential to the long-term viability of the barriers against nuclear proliferation. And no serious analyst of American security interests can doubt that those barriers are vital.

A second peculiar argument has also crept into the rationales opposed to a CTBT. Because the average size of U.S. weapons has come down in recent years, some assert that testing is necessary to shrink nuclear weaponry. Megatonnage has indeed diminished in the U.S. arsenal, but that was an incidental byproduct of the quest for more efficient and capable systems. Furthermore, the suggestion that the trend has amounted to a "build-down" in U.S. capabilities is totally misleading. In the weapons of greatest potency, strategic ballistic missiles, the United States has increased the number of independently targetable warheads fourfold—from under

2000 to almost 8000—since 1970. Similarly, the dramatic surge in Soviet ballistic warheads has brought them to parity in that period.

It is that vast expansion in the most advanced weapons that is the principal result of continued testing during recent years. I leave it to members of the Committee to reflect on the question whether the United States would be more secure today if a CTBT twenty years ago had reinforced the quantitative limits of the SALT I agreement to hold both nations' ballistic missile forces closer to 2000 warheads than to 10,000.

From these observations it will be apparent that I believe the arguments for a CTBT have gained strength. Without rehearsing all the objections to such a ban, let me state simply that I have examined them and do not find them, on balance, compelling. In particular there are a variety of measures that should suffice to maintain confidence in the reliability and operability of the stockpile—especially when that task becomes paramount and the insistence on continuous design innovation is suppressed.

But I have a larger mission here today than merely conveying a judgment that a CTBT is feasible, verifiable and worthwhile. The fact is that those who are shaping U.S. policy do not share that opinion. For that reason a CTBT is not presently achievable. There is no realistic prospect that the Administration will pursue a comprehensive test ban. Thus the practical question for those who are dedicated to forging a sturdy bipartisan coalition on these matters is far more difficult. Are we condemned to a perpetual cleavage on this issue? Or can one define a middle ground that meets the principal objectives of those on both sides of the dispute? I believe there is a sound compromise to which we should all repair.

That compromise would build upon the prior action by both the House and the Senate in calling for early ratification of the long-stalled Threshold Test Ban Treaty and Peaceful Nuclear Explosions Treaty. The plan would involve three elements:

(1.) The United States and the Soviet Union (together with other nuclear weapons states, if possible) would each undertake to conduct no more than five nuclear tests per year. Such a quota would be more than ample to maintain confidence in existing weapons and would even permit some development work, albeit at a reduced pace. But it would sharply curtail the projected rate of testing; four years or more would be required to complete tests that might now be run in a single year. Thus it would respond credibly to the demands of other parties to the NPT that we make progress toward a comprehensive ban. And it would meet the Administration's stated requirement for some testing to assure stockpile reliability. That central argument against a CTBT has no standing as an objection to a quota on tests.

(2.) The threshold for tests would be lowered in steps over a five-year period. The sequence might well be one of annual cuts to 75 kilotons, 50 kilotons, 25 kilotons, 15 kilotons, and ending with a 10 kiloton limit in the fifth year. (I understand that one of the nation's premier nuclear scientists, former Secretary of Defense Harold Brown, has recently testified that he, too, believes the threshold could be cut to the 10 kiloton range.) Reductions to lower levels beyond that period would remain negotiable. In theory a CTBT could eventually result from further curtailment of the threshold in later years.

(3.) Coupled with the numerical quota on tests and a declining threshold, the United States should propose a five-year verification experiment to confirm our ability to enforce a comprehensive ban. General Secretary Gorbachev has now spoken a good deal about his willingness to undertake far reaching arrangements to ensure compliance, including on-site inspections. He should be persuaded that confidence in any eventually comprehensive ban would be enhanced by installing and demonstrating verification systems during a period in which a limited number of tests are actually in progress. In conjunction with the Threshold Treaty ratification and related actions, the parties would exchange important geoglogical data and calibration information that should do a great deal to eliminate lingering concerns about possible cheating or deceptive test programs. A five-year plan to refine cooperative vertification measures would also testify to the superpowers' good faith in attempting to meet their obligations under the 1963 test ban agreement and the NPT.

The importance of the verification experiment goes beyond the issue of nuclear testing. If we are ever to achieve the ambitious force reductions both Moscow and Washington now advocate, it is imperative that the two sides have available tested and accepted methods for monitoring compliance. The exercise of cooperative arrangements for test verification could contribute crucial data and procedures for the larger process on which the President has focused so much attention.

For those who favor an immediate CTBT this proposal will seem inadequate. Yet it promises to lay the groundwork on which a later decision could establish a comprehensive prohibition. And those who demand all or nothing should recall that the

campaign for a CTBT has so far produced—nothing. An incremental approach of the sort sketched here surely has promise for attracting the support of men and women of good will, whether proponents or opponents of a CTBT. And unless we can rally that majority of patriots, the prospects are for a festering and debilitating dispute that will in no way serve the nation.

We have reached a moment when new initiatives are needed to revive the faltering dialogue that opened with President Reagan's re-election and Secretary Gorbachev's arrival in office. More than anything, the quota test proposal outlined here could produce an early success that could pave the way for larger achievements. It could help create the affirmative political climate without which little may be accomplished.

Mr. Reagan enters his final thousand days as President with the Soviet-American relationship tangled in difficult knots and the arms control process stymied. The Senate would serve him and the nation well by injecting new ideas and fresh momentum toward the worthy goal he set in his first term: reversing the trend toward ever-greater nuclear arsenals. The counsel of this committee on the nuclear test dilemma could prove historic in advancing that cause.

Senator WARNER. Thank you, Dr. Frye.

We are not disappointed in any respect by the substance and the content of your superb performance and presented like a true veteran.

We all, I think, share the goal expressed by our President that in fact someday we can eliminate from the face of the Earth nuclear weapons.

First, I would like to ask you what have we learned here in the last 72 hours in view of the tragic episode in the Soviet Union from the burning of their nuclear plant that impacts on the issue before this committee this morning, namely, testing, and indeed, in my judgment, has long range and profound implications on all aspects of nuclear energy, be it in the private sector or in weapons for years to come?

Dr. FRYE. Mr. Chairman, I agree that what we have seen in this tragic episode in the Soviet Union is likely to have quite a profound impact not only on the question of civilian nuclear power, but on political context in which we talk about the security programs of both sides involving nuclear energy.

I can only speculate, but I think at least two phenomena are likely.

First, the mounting outrage in Europe over the failure of the Soviets to inform their neighbors of the hazard will surely produce strong political pressure, perhaps even within Eastern Europe. The Poles are obviously very distressed by what is happening in their own region.

It will increase the political pressure very substantially for the Soviets to undertake the more substantial information exchanges that can make possible greater safety.

Senator WARNER. If I may interject at this point, this would have been the precise moment for the new General Secretary Gorbachev to have shown leadership by stepping forward to break almost a century of history of secrecy and seclusion and it would have caught the attention of the world and instilled in that man and in his new government a sense of credibility. He missed this opportunity.

Dr. FRYE. I think there is a lot to that, Senator. I do believe that it is noteworthy that they have reached out for technical advice apparently from Sweden and Germany. There has been some information exchanged, I understand, with West German nuclear engi-

neers, which I have not seen and which I, frankly, do not know about.

I think there may in fact be a crack in that information control armor which did not occur perhaps in the most timely manner, but which may be a wedge, an opening crack, that will lead to the more forthcoming posture that you correctly indicate is necessary for a full pledged development of cooperation in the management of these kinds of activities.

I do think the pressures will be very much in that direction, both from our friends in Europe and very much from the Soviet Union's own allies.

The second question, which I am more tentative about, is the impact on the Soviet power structure. Anyone is going to be on very thin ice speculating about that, but precisely because we have seen some signs from the new General Secretary that he will emphasize candor, openness, self-criticism, I think there is some reason to believe that the aftermath of this tragedy will see a thorough self-critique within the Soviet system that could produce a greater disposition for information sharing of the sort that could help both in the civil reactor programs and in the negotiations on nuclear testing and related matters.

I say that partly in the context of repeated references he has now made to his willingness to entertain on-site inspection.

I also mentioned, as I commented to you before the hearing began, that the Soviets have inched toward a measure of openness, inviting international safeguard inspections of some of their civil reactors. I do not believe the reactors in Kiev have been inspected, but there have been some inspections under the International Atomic Energy Agency auspices within the last 2 years.

Senator WARNER. I want to contain my questions to 5 minutes in view of the members here, but I just close with this observation that we are really at a crossroads on this issue of verification as a consequence of this tragedy.

If they move in the direction of greater openness and cooperate in resolving this problem, there may be a foundation laid for greater cooperation in arms control. But if they do not, it would push us further in the direction of requiring greater means of verification to support any framework of arms control.

Dr. FRYE. I do not dispute that that is a branch point we have reached. The thing I would want to be wary about is predicting Soviet behavior in the circumstance.

Even if Gorbachev has the instinct to go toward more open postures, we have to recognize the burden of history, the power of the culture, the fact that Soviets may hunker down, they may be so reluctant to display their shortcomings that we may see, at least for a time, a defensiveness in sharing of information about this which would fit with their history better than a tilt toward a more open exchange.

I would take a fairly patient view of that. The ideal outcome would be the one you described, a timely decision by the new Soviet leadership that this is a moment symbolizing the necessity for a more open, forthcoming position.

If we do not get it immediately, however, I would keep open in my mind the likelihood that we could elicit such a forthcoming position in the course of serious negotiations.

As I mentioned earlier, the fact that we have not resumed negotiations on a comprehensive ban, recognizing that that does not commit us to immediate acceptance of a comprehensive ban, but the fact we have not resumed those negotiations may have denied us some information about exactly how far the Soviets would be willing to go on the verification issue.

Senator WARNER. Thank you, Doctor.

Senator Exon.

Senator EXON. Thank you very much, Mr. Chairman.

Doctor, let me associate myself with the remarks of the chairman in thanking you for coming back here and your patience because of the situation we ran into yesterday.

You heard all of the testimony yesterday and some of the questions that I asked of the administration witnesses. I am going to ask you essentially the same questions and give you a chance to respond and give your perspective on a concern or two that I have.

You remember that I asked them that if both sides stopped testing today, which side would be in the best position as far as nuclear strength is concerned, or would we both be in a tie?

Dr. FRYE. In my opinion, Senator, it would be a wash. We would essentially suffer the same limitations in both the programs.

I think I need to comment, though, that the question is perhaps best answered by evaluating the experience we have had over the last 20 years without severe test restraints. It is, of course, the case that there have been more nuclear tests by both the Soviets and the United States since the Limited Test Ban Treaty than occurred before.

On our side something on the order of 600 nuclear tests have occurred since then and the Soviets have conducted hundreds as well. In that interval we have seen the vulnerability of American strategic missiles go from a range in which we were confident they would survive to a range in which we are very unconfident they could survive a concentrated attack by the Soviet missile force.

I think the experience in the last interval of testing is quite demonstrable. It is a decline in the survivability of the American strategic deterrent, a decline in our confidence in its survivability, and pressure, as all of you in the Senate have seen, for a constant pursuit of a solution to the land-based missile vulnerability problem.

It has driven every strategic debate over the last 10 or 12 years. It is the story of MX, it is the story of Midgetman, it is the story of the window of vulnerability, and the entire change in emphasis from the late seventies to the Reagan era.

All of that derives from the fact that there has been uninhibited underground testing for the development of powerful weapons for counterforce attack.

Having said that, there are a couple of additional points the committee needs to know. Today, right now, the relative vulnerabilities of the two sides so far as their land-based ICBM's are concerned are markedly different.

To put it in a nutshell, and I draw here on published North Atlantic Treaty Organization data and JCS military posture statements, the Soviets have deployed a powerful counterforce capability which threatens every one of our fixed silo ICBM's. They can take out virtually all of our ICBM's in a hard target attack with the numbers of weapons and types of weapons they have.

In so doing, they would eliminate less than 25 percent of American warheads.

We, on the other hand, have far less counterforce capability for prompt attack, although the JCS numbers show in overall hard target attack capabilities the ratio is very close. Our bomber follow-on counterforce is very good. It cannot do it in 30 minutes, but it can take out hard targets very substantially in 36 hours.

In prompt hard target capability, though we have only a fraction of what the Soviets have, their vulnerability is stupendously great.

The NATO numbers suggest that we could destroy in prompt attack more than 800 targets by a two-warhead on one silo attack.

Gentlemen, the Soviets have well over 50 percent of their warheads in fewer than 800 targets.

So, to summarize, today's situation is that the Soviets have a larger counterforce capability, we have a lower vulnerability, with only 25 percent of our weapons at risk.

The Soviets have a much greater vulnerability because, with our counterforce, we can destroy more than 50 percent of their strategic warheads.

Now, in that context the reality I would expect after a comprehensive ban would be a shift in the direction of continued refinements in accuracy, missile delivery, and other capabilities.

The situation in which there would be a comprehensive test ban, I would submit, would not change in any significant degree the quest for continued counterforce capabilities, building upon improved accuracy. That competition would continue with no impact whatsoever from a nuclear weapons test restraint.

Senator EXON. Mr. Chairman, my time is up.

Senator WARNER. Senator Levin.

Senator LEVIN. Thank you, Mr. Chairman.

I join in your thanks and Senator Exon's thanks to our witness.

I admire your optimism, your incremental approach. It is welcomed. I doubt that progress will be made incrementally without folks pressing for a little more drastic solution to this problem. The fact that you have taken the time and have the enthusiasm to press that cause I think is very, very helpful indeed.

By the way, what would be the impact of your proposal on our so-called modernization approach?

What are the arguments that the administration uses for ever resuming negotiations on a CTB? Is the issue not whether we enter into a CTB or whether we resume negotiations, but conditions under which we enter into a CTB as promised?

One of the reasons for not resuming negotiations by the administration is that it would hinder our need to create new generations of weapons.

What is the impact of these proposals on new generations of weapons 5 years down the road?

You would phase it down to ten kilotons. Either way what is the impact on the President's desire for new generations of weapons and what is the impact down the road?

Dr. FRYE. Dr. Barker mentioned yesterday that some of the nuclear weapons testing associated with warheads for those systems has not been completed. That is specifically true for the planned enhancement of the D–5 missile.

It is my opinion, and it is a judgment call for the administration as well as for private analysists—it is my opinion there would be no significant impact on either possible MX deployment or a small ICBM deployment, the Midgetman which can use that warhead for the MX.

Senator LEVIN. Under your proposal?

Dr. FRYE. Under my proposal.

Senator LEVIN. How about on the D–5?

Dr. FRYE. On the D–5, it is also my opinion, first of all, it is a missile configured for possible use of the existing warhead from the C–4 missile which would be quite substantial and quite capable when mounted on the D–5.

It will not have all the capacity, but given the accuracy improvements expected for the D–5, the accuracy improvements that would continue, given the accuracy improvements, it would become a rather potent counterforce system even if it could not have the new warhead planned for it.

There is one other point. I am not clear that under the declining threshold I described it would be beyond the lab's capacity to conduct the tests for the D–5 warhead. I think it is possible that some reconfiguration of the test program would in fact complete that program satisfactorily so that the new warhead for the D–5 would also be testable to satisfactory levels under the declining threshold.

I think it has no significant bearing on the warheads for our air-launched cruise missile program which is the other big buy in nuclear warheads during this interval.

Senator LEVIN. What about star wars?

Dr. FRYE. Senator Kennedy and I spoke briefly at the end of yesterday's hearing when he asked Dr. Bethe about that.

A threshold ban would have very limited impact on even nuclear test programs associated with SDI. Much of that could continue. The fact is that for the kinds of x-ray lasing phenomenon described as one of the prime candidates for the SDI, you are facing not a problem with the threshold that I propose or the threshold treaty we already respect. At the appropriate moment, that system will essentially not be one in which you could have confidence unless we test it in outer space. It would have to be, in fact, something that would cause us at a certain point to decide to abandon the Limited Test Ban Treaty as well, in my opinion.

Senator LEVIN. As well as the ABM Treaty?

Dr. FRYE. Yes.

Senator LEVIN. That is only two treaties. What the heck.

Dr. FRYE. The threshold proposal has very little impact on SDI.

Senator LEVIN. Very few other treaties would remain intact.

Dr. FRYE. I understand why you are driven to that troubled touch of wryness. I know you are perplexed by the situation those treaties are in. So am I.

I think our security remains importantly tied to managing a relationship with an adversary we cannot overpower. I believe for that reason that we are far wiser to build upon and improve the treaties we have already established, supplementing them with more detailed and refined agreements, than we would be in abandoning those agreements and entering an unregulated strategic competition.

Senator LEVIN. My time is up.

Senator WARNER. Senator Kennedy.

Senator KENNEDY. Thank you, Mr. Chairman.

I want to join in welcoming you to the committee.

I would like to follow up on Senator Exon's question about which side would be more disadvantaged if we had a CTBT. One point we have heard time and again is that the configuration of the American stockpile is different from the configuration of the Soviet stockpile, not with respect to the location of the various weapons systems, but in terms of the relative sophistication of each side's nuclear devices. We are told that the United States has a greater reliance on testing because of the greater technical sophistication of our devices.

Could you address that issue in terms of the debate over stockpile reliability.

Dr. FRYE. It has always been the impression I gleaned from many encounters and some years in close association with the Strategic Air Command and others during the years I worked for the Rand Corp. and subsequently, it has always been my impression that the confidence we feel in the reliability of our weapons is very great indeed, both in the delivery system's performance, the capacity to get out of the silo quickly, if necessary, and the capacity to deliver a weapon that will work at the other end of the trajectory.

I recognize that our systems are very sophisticated and with sophistication we have seen sometimes reliability problems intrude from other directions. But our test program has addressed that for 20 years.

For that reason I feel very considerable confidence in the judgment that our systems will be reliable over a protracted period of time, especially when we continue to focus on maintaining that reliability by the enormous range of test operations we could continue to conduct.

For example, I know that Senator Quayle was very concerned yesterday about satellite component vulnerabilities. There are parallel questions about missile component vulnerabilities. Many tests in regard to that kind of component would continue to be possible.

The lab tests with high explosives, x-ray tests to determine reaction to x-ray spalling, in a vacuum, if necessary, we can do it. It would be possible to continue exposing those components to particle bombardment and particle beam accelerators. There are many things we can do that tell us a good deal of what we can get out of weapons effects tests.

I think we can be confident to a considerable degree that our systems will remain reliable. I cannot make a judgment about the Soviets. My opinion is that they would have less confidence over the years in their systems than we would retain in ours.

Senator KENNEDY. Let me move on to the area of verification. New technology in the form of a more sophisticated method of seismological monitoring, has been developed in recent times.

How important is the new "high fequency" monitoring in helping us to assure adequate verification for a CTBT?

Dr. FRYE. I am not a participant in the test program or the seismic technology work, so I can only speak about it secondhand.

Partly because we have conducted so many tests, we have monitored many tests with perfect calibration data about the soil in which we conducted the tests and scale of our systems, that has given us confidence from one source.

Second, we and other states, the Swedes in particular, have monitored very closely Soviet test activities and have gained increasing confidence that we can bracket the zone in which they occur taking account of different geologies very well.

What I tried to present before you arrived was my sense that the consensus of the scientific community is quite different from the view conveyed by the administration witnesses yesterday. It is different from the concerns many of us had when we worked on the 1963 accord in the Senate.

Today, by contrast with that era, the scientific community seems to me to be quite confident that it has narrowed the zone in which plausible test cheating could occur. For that reason there is increasing confidence that verification will do the job.

Senator KENNEDY. Could you address the point that has been raised by some administration officials that if we were to achieve a CTBT, that there would be further proliferation, both by nuclear countries and nonnuclear countries?

This is a rather novel analysis.

Dr. FRYE. Yes, it is novel.

Senator KENNEDY. Would you address that?

Dr. FRYE. I do not think it is a meritorious argument, Senator. I made reference to it in my opening statement also because I think it is one of the more bizarre rationalizations we have seen in this debate over any period.

If we become less confident in our stockpile and those dependent on us for nuclear deterrence become less confident in our stockpile, then theoretically at some level somebody might say they had better get their own. But look at it concretely.

Which Government in its right mind would reach the conclusion that it could safely field an untested weapon—because we are talking about an environment in which they would not be testing either—which would prefer to have an untested weapon in small numbers as a deterrent compared to continued protection of the American nuclear umbrella with thousands of warheads, elaborately tested designs, more than 800 tests over 40 years? How many people would make that as a tradeoff?

More importantly, every message we get from the international community, most recently in this European panel on nonproliferation, whose work I reported on briefly here—every message we get is that the superpowers are not living up to their obligations to pursue a comprehensive ban and to reduce their own arsenals. That places in jeopardy the obligation of other states to respect their commitment not to acquire nuclear weapons.

That is the thrust of the international debate. It has no relationship whatsoever to this extraordinary speculation that somehow test restraints would encourage proliferation. I think it is as close to nonsense as I have seen in a public statement.

I am being tempted by your question to say something stronger than I wish because my objective is not to divide our community, but to heal it because I think it is already divided.

Let me stop simply by saying I think that is not a serious argument for anyone's consideration.

Senator KENNEDY. My time is up. I will submit my additional questions to be answered for the record.

Senator WARNER. The Senator from Illinois.

Senator DIXON. Thank you, Mr. Chairman.

A couple years ago when we were involved in the debates in the Senate about the basing mode for the MX missile and generally discussing the basing mode for land-based missiles, many of the Senate, including myself, felt that a mobile and deceptive type of basing mode would be preferable to placing the MX in those silos in the West, the exact location of which is known by the Soviet Union.

There were lots of arguments made at that time by the administration. Since the evidence has developed that clearly the Soviets are moving in that direction now, I believe with their 24's and 25's as mobile missiles.

Dr. FRYE. Certainly the 25's and possibly the 24's.

Senator DIXON. Why do we not more seriously consider that type of alternative in view of what I consider is a substantial body of opinion that that fixed type of basing is very vulnerable?

Dr. FRYE. The question is central to the whole debate on survivability of the strategic missile force. I think your premise is correct.

I would remind you that in fact the House and Senate had moderately close votes, but they had supported a multiple protective shelter basing scheme for the MX during the late seventies.

The irony that the MX presents is that the President who was very skeptical about the need for the missile and desirability of building another big, capable, counterforce system, authorized its deployment if a survivable basing mode could be found that Congress approved.

The irony is that President Reagan, deeply committed to the MX, ruled out in his first decisions the one basing mode that would have won congressional support. I think every record vote prior to that time makes quite clear that if the President had made the proposal you have just made, that the MX would be going forward now in a multi-shelter, deceptive basing mode.

For reasons that were quite important to the President he chose not to do that. We are now in an entirely new environment and new context. Part of that context is the Soviet move toward mobility.

I know Ambassador Rowny picked up quite clear signals, as he has made evident from time to time, that the Soviets were moving toward mobility because they were aware of this extreme vulnerability I described earlier.

Senator DIXON. If I may interrupt, we are both moving in opposite directions.

Dr. FRYE. We are moving in opposite directions with regard to the MX. I was going to add that another element to the context is, of course, the bipartisan consensus that emerged in connection with the Scowcroft Commission that called for a mobile option for the single warhead, small ICBM.

I think there is a strong case that the best option of all remains a survivable single warhead missile which would not be a magnet for attack. Mobility is a very important aspect of making sure that missile has the option to survive. I know it is a point of some concern in the committee still.

Senator DIXON. One more question, If I may, Mr. Chairman.

My colleague from Michigan talked about Star Wars. In my State of Illinois there is kind of a curious response. I supported the strategic defense initiative. Argonne Laboratories is beginning to produce some of the work involved in this whole research question. Our chairman, Senator Goldwater, has indicated several times in some jest, but I think also honest candor, that nobody really understands what we are doing here.

One of the problems in my State is that a great deal of the universities and the leaders of those great universities in my State decline to become involved, saying it cannot work. It is a waste of money, it is a hallucination, this is fantasy.

What is the truth? What kind of progress are we making? And what is the reality of what is called the strategic defense initiative?

Dr. FRYE. Senator, if you will bear with me, I will have to answer that philosophically. There is one precise point I would make with regard to the subject of this morning's hearing.

Senator Exon asked about the State of balance between the two superpowers in the presence of a nuclear technology restraint. On one point it should be clear.

General Abrahamson has stressed he thinks the Soviets themselves are farther along on x-ray laser testing than we are. If we wished them to pursue that particular SDI potential, then obviously continuing testing will permit them to do that.

Looked at from that standpoint in the test debate, continued testing may be a case in which on that particular SDI element the Soviets might have a bit of an advantage according to General Abrahamson.

Now, the question you put really does require a philosophical answer. I think there is fundamental confusion about the nature of the strategic defense problem. There is no one in America who would not wish to see our people protected if we knew how to do it and if we did not perceive serious instabilities associated with trying.

So, there is no question about the ideal, the appeal of being able to protect our Nation in the face of this terrible threat.

The problem is that it is not a scientific issue. The President framed it as one in which our scientists could solve the problem. It is only in a trivial sense a scientific and technical problem. Einstein caught the right theme. Einstein, in one of his famous maxims said, "God made me subtle, but he isn't mean, he isn't malicious."

What he meant by that was that a scientist could pursue his research in to the universe knowing that the rules would not be changed, it would not be a hostile God changing the rules to confuse you. That is the difference between scientific research and the kind of competitive military research associated with SDI.

This is not man against nature; this is man against man. There is no technology we have yet identified for SDI for which we have not already identified a plausible countermeasure, a countermeasure which an adversary could well pursue. That does not mean we know enough to know which is the best countermeasure any more than we know enough to say what is the best SDI option.

I would have to stand with Harold Brown. He just published an article in *Foreign Affairs* in which he made very clear that the heart of the problem is that the technologies that are most promising for SDI are also most promising for suppressing SDI-type systems. They look even better as defense suppression techniques than they do as antiballistic missile techniques.

I think he has captured the gist of the present technical reality. The philosophical reality is that this is not a scientific enterprise; it is a competitive man-against-man exercise for which one has to reach a very different judgment than if he were simply asking could one in fact do some of these things in the face of a nonhostile environment.

Senator DIXON. Thank you.

I thank the Chair.

Senator WARNER. Senator Nunn.

Senator NUNN. Mr. Chairman, let me suggest that since our colleagues have been here and heard all of it, rather than duplicate some of their questions, I will say I will waive my round and I will come back a little later.

Senator WARNER. I would suggest we take questions and move along quickly so that we can all participate. This has been an extremely valuable session.

Dr. FRYE. Mr. Chairman, before you proceed, could I add one footnote to my comment to Senator Dixon?

I think the most important rationale for a substantial program of strategic defensive research is in fact the necessity to hedge against Soviet breakthroughs in that area. I do support substantial funding of research in this area.

I think the test is, the requirement is, how do you draw the line so that it remains research and does not cross into a development and deployment phase which would trigger not only competitive defensive activities, but probably a substantial increase in the threat.

I want to make clear a substantial program in strategic defense research is necessary because it is a competitive relationship. We dare not allow the Soviets to get far ahead in this area.

Senator DIXON. I appreciate that.

Senator WARNER. Dr. Frye, we recognize here in this committee and, indeed, throughout the Senate your extensive credentials in a broad range of areas involving foreign policy and you are a student of the executive branch and the Congress.

My question to you is this: There is a strong disposition in the Senate now that we should move on particularly the Threshold Test Ban Treaty.

My concern is, putting aside all partisan consideration, that the President under the Constitution remains the Chief Executive of all our foreign policy. I do not want to see the Congress moving in a manner that contravenes his constitutional responsibility.

What would be the procedure that you would recommend be followed by both executive and the Congress to proceed toward a resolution of whether or not we can or cannot—let us single out the CTB—move on that in the terms of ratification, bearing in mind that this Nation is engaged in and has made certain commitments to the Soviet Union with respect to the summit process?

In my own judgment, the decision to move on this treaty in a manner consistent with the mutual interests of both nations should arise out of the summit process. That is my thought and I would be interested in receiving yours. You are aware of what the House has done in their resolution?

Dr. FRYE. Yes, I am. I am deeply concerned about the Constitutional balance, as you are, and believe we have to assess it not only carefully, but with a full appreciation of the political realities between the administration and the Congress today.

One of those realities, which I think one can state without appearing to become cynical, is that many Members of the Senate have worked on these issues far longer than the President has. He is new to these questions and he is relying on the advice of his administration, not on the basis of a personal and detailed knowledge.

There are students of these issues within the Senate, the staff and among the membership level, who have followed this question for many years.

I was pleased to see Senator Stennis here yesterday. I have many years and days in which I have enjoyed the pleasure of being in this committee with his leadership. I was always impressed with the judicious quality he brought to deliberations of this nature. He, too, as many of us, respects the President's prerogatives.

But when we have a President who is not, himself, steeped in an issue of this complexity and of this importance to the country, I think it is appropriate for the Senate to consider ways in which it can emphasize the advice portion of its advice and consent.

Now, what form might that take? Again, if you will permit me a retrospective observation, in 1969 and 1970 the Senate considered and passed overwhelmingly by a vote of 72 to 6, a resolution urging a mutual suspension of MIRV testing and deployment.

In that respect, the Senate's wisdom was far greater than that which governed executive policy at the time. I have heard senior officers of the Strategic Air Command within the past month make that point. We made a mistake by not pressing hard enough to get the MIRV issue into the negotiations.

The Senate made clear it was offering an advisory resolution with no teeth. That experience and the significance of that experience tilts me as a private observer toward great skepticism about relying only on the bureaucratic advice the President tends to receive at this juncture.

So, I do feel well disposed to the Senate finding a formulation which permits it to nudge the process forward, preferably in the summit context. I have not, myself, tried to draft for friends in the Senate anything that addresses that question, but one can invent ideas.

One could conceivably have a Senate expression that would help the President get out of the bind in which he finds himself on this issue. Let me describe the bind.

As you heard yesterday, despite what I reported as the wider technical consensus that verification is now feasible, the President is continuing to hear an argument that says it is not feasible and a threshold ban cannot be ratified without major changes prior to ratification.

He, therefore, would be in a position of saying, "I was wrong, we can verify it," if he says he is willing to have it ratified at this juncture. That is a problem for him. I understand it.

Could he be helped by the Senate making clear its ratification would be offered but perhaps suggesting that the only change in the treaty might be a change in the effective date, giving an interval so some further discussion of verification could take place?

I have not framed that well, but one might conceivably press the President to suggest to Mr. Gorbachev that we would proceed with ratification, but that following Senate action, the President, himself, would expect an interval to pass, perhaps 6 months, for further discussion of the verification issue before the exchange of ratification instruments would occur.

This is strictly an invention of a device to provide an interval in which the discussions on verification which the President says are essential could take place. I do not believe those verification supplements are necessary, Senator.

I think the treaty, particularly if ratified in conjunction with the PNE agreement and exchange of geological data and calibration information for which these agreements provide, in that context, I think the Senate could proceed even without any adjustment at all with the verification arrangements.

But if the President feels he has to stick to the present position, perhaps one could invent something like a delay in implementation that would provide an opportunity after ratification by the Senate for completion of verification arrangements between the two Governments.

Senator WARNER. You do not believe in the CORRTEX?

Dr. FRYE. I think CORRTEX is a very welcome addition.

Senator WARNER. But it is not essential?

Dr. FRYE. I do not think it is essential, but it is a very welcome development. Nothing I would say would discourage the attempt to pursue the things the President has already proposed, an exchange of observers at test program sites and the demonstration of CORRTEX technology.

I am all for that, but I am saying that, in my opinion, that becomes more important in subsequent phases of verifying a shrinking threshold. Those verification systems become much more important at much later stages. For a 150-kiloton Threshold Test Treaty I think they are not of great significance.

Senator NUNN. What do you think of the Senate's inviting the President to submit any specific reservations he might have to the PNE and the Threshold Treaty and deal with those on the matter of verification?

Dr. FRYE. I think it is a plausible approach.

Senator NUNN. Go ahead and have the Senate ratify the treaties with reservations? After all, the administration is saying their only problem is verification.

Dr. FRYE. I cannot vouch for how the Soviet Government might react. They always object to reservations, obviously. Frankly, I think that is a sound approach. I have been more troubled than I can say by the difficulty of pinning down exactly what the verification problems are that the administration has seen.

You and the commitee may have heard full and elaborate testimony that persuades you that they have defined what the verification problems are. I have not seen it.

Senator NUNN. I do not think I have seen it either. From what I have seen, that would be the time to ask him to send whatever verification problems there are and we could deal with them.

Dr. FRYE. That is a perfectly sound and straightforward approach, Senator.

Senator NUNN. May I ask a series of questions here? I will not take but just a moment.

It is my understanding that the administration policy on the comprehensive test ban is that it is not yet time to undertake such negotiations.

Is that your understanding?

Dr. FRYE. That is my understanding.

Senator NUNN. I also understand that the administration's position is in quoting that position that it remains "our objective which we would seek to pursue within the context of broad, deep and verifiable arms reduction."

Is that your understanding of it?

Dr. FRYE. That is what they continue to say.

Senator NUNN. Following the line of reasoning, that implies that if the Soviets were to accept our current arms control proposals on the table, to start that would put us in a different position regarding a comprehensive test ban, would it not?

Dr. FRYE. I think it does. Perhaps I am a little cynical about it, but, quite frankly, we have seen the erection of new objections as some original objections were satisfied. Particularly as verification has gotten better, new questions of this nature are being introduced.

Senator NUNN. They are saying that we are not ready yet, but if we do reach an agreement in the other areas, START, and so forth, then we would have a different view towards following that line, when we reach the START agreement, do we not reduce inventory on both sides rather dramatically?

If the U.S. proposal is accepted as it is now, both sides would reduce their inventories of warheads?

Dr. FRYE. By almost 50 percent.

Senator NUNN. Would not that make the reliability of weapons, if that is your objection to a comprehensive test ban, more important rather than less important?

Dr. FRYE. In logic, it would.

Senator NUNN. If our START proposal were accepted, it seems to me that the argument the administration is now using against a comprehensive test ban would reinforce rather than diminish.

Dr. FRYE. I think you could expect to hear them taking a different position based on the position that they have made clear already, that is their reluctance to see a comprehensive ban.

Senator NUNN. So, giving the administration credit for the words they have spoken on this subject and giving credit for wanting their own START proposal to pass, it seems to me what they are saying is somewhat disingenuous because they say if we pass a START proposal, then we would be willing to negotiate a comprehensive test ban, but if they do get a START proposal accepted by the Soviets, then it would make their own argument against the Test Ban Treaty stronger rather than weaker.

Dr. FRYE. I believe that you make a telling point and a conclusive case. I also believe that, as you saw in the artful and ingenious testimony by my friends yesterday afternoon from the administration, they are fully capable of finding new rationales to fit the circumstances you describe.

Senator NUNN. Thank you.

Senator LEVIN. Unhappily those rationales are not limited to the future. They have already come up with the extraordinary one about it would promote proliferation which you punctured this morning.

They have also written a few more, I am afraid. "CTB remains a long-term goal of the United States." I think that means the 25th century.

Putting that aside for the moment, "However, it must be viewed in the context of achieving broad, deep, and verifiable nuclear arms reductions, substantial improved verification capability, a greater balance of conventional forces"—we have that one in there—"and at a time when a nuclear deterrent is no longer as essential an element as current for international security stability."

So, they have all kinds of different rationales for doing nothing.

Dr. FRYE. When we return to paradise, Senator, we will leave the nuclear weapons outside.

Senator LEVIN. Have you any additional comments about the tragedy in the Soviet Union in addition to the ones you previously identified?

I think the public is going to increase their demands that governments find a way to reduce the threat of nuclear weapons. I hope so. I hope some good can come from this tragedy in lots of ways, including opening up the Soviet Union in terms of seeking assistance and being honest and direct about their own problems.

I also hope there is an increased clamor. We are going to need it because there is no way we are going to move this administration or no way the Soviet administration will move the way they have to move to reach some kind of accommodation on the treaty.

I would add that to your commentary as to the impact of this accident yesterday. There is going to be, I believe logically or illogically, a natural human reaction to what one nuclear weapon can do.

I do not know how this fallout and that radioactivity yesterday or the day before, whenever the accident happened, compares to what one nuclear weapon would do. I do not have that comparison. I am trying to find it.

Dr. FRYE. I think it is certainly much less than any ground-burst nuclear weapon would do.

Senator LEVIN. I am trying to find if it is a hundredth or a millionth.

Dr. FRYE. It is enough less so that beyond the immediate perimeter of this reactor fire the danger is going to be modestly detectable, but beyond the perimeter of a nuclear ground burst, the danger is substantial.

Senator Levin, if I can frame one point to try to be clear about the message I hope I can leave with you.

It is very evident that so far as a comprehensive test ban is concerned, the administration's position is not "on our watch." So, you know that is not going to occur as a near-term option.

I think the logic that Senator Nunn put forward is very interesting and important. The judgment I submit we need to make as a nation is whether or not some progress toward constraining nuclear tests can serve the larger potential process of facilitating reductions.

The argument I hope I have put to you is that in fact if we can forge a consensus that a quota test ban, declining threshold or some similar device will permit a negotiable arrangement with the Soviets, permitting us to learn a bit more about how to verify, we will have taken a giant stride toward the very reductions program the President has emphasized.

I think our task is to reconcile these objectives, not to paint them into concrete as diverse and conflicting objectives.

Senator LEVIN. I think your point is clear and very well taken. I think you are overly optimistic about the President listening to the wise folks in the Senate. We voted 77 to 20 a few years ago urging him to renew negotiations on a comprehensive test ban. That was when he was even greener, even with less knowledge than he has now relative to folks that you say he should be listening to in the Senate.

A request of the Chair, if we are not coming back this afternoon——

Senator WARNER. Not in this forum.

Senator LEVIN. Could I ask a number of documents be inserted in the record, including a letter to Chairman Fascell from a number of arms control experts and an article from the New York Times. Testimony of Dr. Sykes in the House on May 8 and the response by Professor Sykes to a number of additional questions which were submitted in the House should also be inserted. (See p. 84.)

Senator WARNER. Without objection.

The Chair will consult with Senator Nunn on the propriety and advisability of having a follow-on hearing that will be largely for receiving classified testimony.

Senator LEVIN. Again, I thank the Chair for calling this hearing.

Senator WARNER. It is my recollection you were among the very first ones to request it.

Senator NUNN. Thank you, Dr. Frye.

Dr. FRYE. Thank you, Senator.

QUESTIONS SUBMITTED BY SENATOR EDWARD M. KENNEDY

Senator KENNEDY. If we and the Soviets were to gradually reduce the threshold of testing from 150kt to 10 kilotons in 5 years, as you propose, what kinds of testing would it prevent us from conducting?

Could we continue to conduct reliability tests?

Could we continue to improve the safety and security of our weapons?

Could we test the nuclear-pumped x-ray laser for "Star Wars"?

Dr. FRYE. It is important to preface a judgment on the kinds of testing that might be possible at lower thresholds by noting that many weapons currently in the stockpile have larger yields than those at which we have been testing for the past twelve years. We have already been maintaining the reliabilty of deployed forces with warheads much greater than the 150 kiloton maximum yield currently permitted for testing. The question, then, is how far down the scale of nuclear yields one can proceed and still be satisfied that weapons now deployed with much larger yields would continue to function reliably.

Opinions will very substantially. Dr. Bethe has told the Committee that he believes "zero-nucler-yield tests" would be practical and sufficient to maintain confidence in the reliability and operability of the deployed systems. While a 10-kiloton threshold would obviously preclude a number of the tests currently conducted as well as some of those planned for future years. I share the widespread view of the technical professionals that such a threshold would be more then adequate to maintain confidence in existing weapons. Furthermore, a gradual phase-down of the threshold over a five-year period would permit some rescheduling of planned tests to accommodate a few relatively higher yield explosions early in the period when the threshold was still fairly high.

The critical point to remember is that nothing in the reduced threshold concept would diminish our capability to conduct full-scale tests of high explosive components of the weapons, as well as the chemical, radiographic, and structural tests which are important to ensuring reliability. Indeed, one might expect somewhat greater ingenuity, given the incentives of a reduced threshold, in devising such non-nuclear-yield tests and inspections. Those same procedures would make possible continued improvements in the safety and security of the weapons, particularly since the safety and security enhancements could be tested in a nuclear environment below the threshold. (If the argument is made that such safety and security improvements are feasible only if tested at the full yield of the deployed weapon, clearly we would be failing to meet that standard already in a number of cases.)

I cannot offer a firm judgment on how constraining the lower threshold would be for the nuclear-pumped x-ray laser. I do not know the specific physics well enough to assert that adequate exploration of the phenomena is practicable at low yields, although I am unaware of evidence indicating it is impossible to create such effects at low yields. If such phenomena are not achieveable below 10-kilotons, and if the concept were considered sufficiently important, it should be possible to conduct some x-ray laser tests in the early stages of a declining threshold.

The crucial points here are two: first of all, the President has consistently emphasized that work on the Strategic Defense Initiative would aim for a non-nuclear system; obviously, the x-ray laser is incompatible with that assurance. Secondly, as I mentioned in my testimony, the critical impediment to development of the x-ray laser is not the prospect of a shrinking test threshold but the fact that adequate testing of any such device would require the violation or abrogation of the ABM Treaty, the Limited Test Ban Treaty of 1963 and the Outer Space Treaty of 1967, since such a technolgy would ultimately have to be demonstrated in outer space. Before worrying about the prospect that a reduce test threshold might restrain the x-ray laser, it would be wise to ask whether the United States wishes to embark on a path that would contravene President Reagan's commitment to a non-nuclear strategic deterrence—and would require the destruction of at least three international treaties.

Senator KENNEDY. Do you disagree with Secretary Perle's assertion in his testimony that "a CTB at this time could encourage the retention and proliferation of nuclear weapons?"

Dr. FRYE. With the greatest respect for Secretary Perle's intelligence and skill, I do not believe any policy should be based on a thin and unsubstantiated speculation that a comprehensive test ban "could encourage the retention and proliferation of nuclear weapons." That speculation runs against the grain of the expressed international consensus favoring a CTB. That consensus is embodied in the Non-Prolifera-

tion Treaty, in numerous resolutions of the United Nations and in the concluding declaration of the 1985 Review Conference on the Non-Proliferation Treaty. It is reflected in the intensive efforts by leaders of friendly governments—including those of India, Mexico, Argentina and Sweden, among others—to make available their good offices and national territory to support a test ban.

Having made clear my own preference for a quota test ban (rather than a CTB), I believe it is more likely that restraints on nuclear testing would strengthen U.S. leverage in discouraging other states from seeking nuclear weapons by demonstrating progress towards fulfilling the superpower commitment to end nuclear testing and begin reductions in their own arsenals. Test limitations would tend to shift international expectations toward an era of mutual restraint between the superpowers; that could help diminish the fears and threats which are the motive forces behind nuclear proliferation. It is far more likely that an unregulated competition in nuclear weaponry, involving perpetual testing and force modernization by the United States and the Soviet Union, will spur other states to acquire what they may then consider to be "legitimate" instruments of mass destruction.

Clearly, we need to think hard about the likely behavior of other states in the context of a comprehensive test ban. International politics is replete with perverse possibilities against which we must guard. But the perverse possibility that a CTB might encourage proliferation is far less plausible than the large probability that the absence of a test restraint and progress in superpower arms control will trigger such results.

Senator KENNEDY. Do you know of any evidence to support the argument that a test ban would encourage other nations to develop their own nuclear weapons?

Dr. FRYE. I know of no such evidence and doubt that anyone else does. I note that in a State Department letter of April 17, Acting Secretary James Dyer states that "we are not aware that any U.S. allies have indicated that the conclusion of a CTB treaty between the U.S. and the Soviet Union might lead them to build independent nuclear deterrent forces. However, inasmuch as the U.S. position vis-a-vis a CTB under present circumstances has been consistently clear, none of our allies has had to address the proposition. * * *"

In fact, the U.S. position has not been consistent but has changed drastically from one which held that a CTB was desirable if verification could be assured to one in which the United States asserts that a CTB is undesirable so long as we rely on nuclear weapons as a deterrent. The evidence is that U.S. allies have favored the repeated efforts by every administration since President Eisenhower's to achieve a comprehensive test ban, subject to satisfactory verification arrangements. It would be a considerable contortion of history to read the record as implying that allies who have publicly favored a CTB as a contribution to nuclear restraint and international security would be moved to develop their own nuclear weapons after the achievement of such a ban.

Once again, let me stress that none of these speculations about the potentially pernicious political consequences of a CTB has any bearing on the impact of a quota test limit. Such a regime would afford ample confidence to us and to our allies in the capability of the American nuclear deterrent.

[Whereupon, at 12:25 p.m., the committee adjourned, subject to the call of the Chair.]

APPENDIX 11

LETTER FROM SCIENTIFIC AND ARMS CONTROL EXPERTS TO CHAIRMAN FASCELL ON WEAPONS RELIABILITY

May 14, 1985

The Honorable Dante Fascell
Chairman
Committee on Foreign Affairs
U.S. House of Representatives
Washington, D.C. 20515

Dear Mr. Chairman,

Continued nuclear testing is not necessary in order to insure the reliability of the nuclear weapons in our stockpile. The best way to confirm reliability is to disassemble sample weapons and to subject the components to non-nuclear tests. Weapons can also be detonated without their nuclear components in order to insure that the complete assembly operates correctly. Nonexplosive tests are also available for determining whether the nuclear components have deteriorated during storage. If aging problems are found in some components, these components can be replaced with newly fabricated ones, using the original design specifications.

In the past these techniques have identified a number of reliability problems. In no case, however, was the discovery of a reliability problem dependent on a nuclear test and in no case would it have been necessary to conduct a nuclear test to remedy the problem.

In any event, it would be completely impractical to conduct the large number of nuclear tests that would be required to establish by this method a statistically meaningful measure of the reliability of stockpiled weapons.

We hope these observations will be useful to you in considering the Comprehensive Test Ban.

Sincerely,

Hans Bethe

Hans Bethe
Nobel Laureate in Physics
former Director, Theoretical Division, Los Alamos National Laboratories

Norris Bradbury
former Director, Los Alamos National Laboratories

Richard Garwin
IBM Fellow, Thomas J. Watson Research Center
Consultant, Department of Defense, Department of Energy

C.I.A. Changes Way That It Measures Soviet Atom Tests—U.S. Charges Questioned

READINGS WILL BE LOWER AND OFFICIALS DEBATE ISSUE OF PAST RUSSIAN CHEATING

(By Michael R. Gordon)

WASHINGTON, April 1.—The Central Intelligence Agency has changed its procedures for estimating the yield of large Soviet nuclear tests because it has decided its previous estimates were too high, Reagan Administration officials said today.

The officials said the decision to use the new method was made in January by William J. Casey, the Director of Central Intelligence, despite objections from some Defense Department officials.

REAGAN REQUESTS A REPORT

The C.I.A. decision has raised questions about past Administration assertions that the Soviet Union had probably violated the Threshold Test Ban Treaty of 1974, which limits undergrounds tests to no more than 150 kilotons.

Before the C.I.A. decision was made, President Reagan ordered a report on how the change would affect Administration concerns about Soviet Union violations, the Administration officials said. That report has not yet been completed.

Mr. Casey formally approved the change on Jan. 21, officials said. Experts familiar with the change say it will lower estimates of the yield of Soviet tests by about 20 percent.

NO WHITE HOUSE COMMENT

Richard N. Perle, the Assistant Secretary of Defense for International Security Policy, reportedly opposed adopting the recommendations and argued that the issue needed more study. Mr. Perle declined to discuss the issue.

Edward P. Djerejian, a White House spokesman, said the White House had no comment at this time on the decision and its implications.

Administration experts, who asked not to be identified, were divided about whether the change should lead the Administration to drop its allegations against the Soviet Union.

The accusations of Soviet arms control violations has become a central issue in United States-Soviet relations. No significant progress has been made in this area since the November summit meeting President Reagan and Mikhail S. Gorbachev, the Soviet leader.

DELIBERATIONS OVER TREATY

The Reagan Administration is currently deliberating over what actions to take in response to reported arms control violations and in considering whether to modify its commitment not to undercut the 1979 Strategic Arms Limitations Treaty.

The Administration has said that many of the Soviet tests had "likely" violated the threshold treaty, which stipulates that the size of warheads being tested should not exceed 150 kilotons, equal to the explosive force of 150,000 tons of TNT. The Soviet Union has denied violating the treaty.

But Administration and nongovernmental experts have long questioned the accuracy of the intelligence estimates on which those charges were based.

The debate has centered on the seismological procedures for assessing the yield of nuclear tests. The main Soviet test site at Semipalatinsk in Central Asia is older and more geologically stable than the site in Nevada where the United States conducts its tests.

LARGER WAVE IS PRODUCED

Scientists say Soviet explosions produce a larger sound wave through the earth than American tests of the same size.

While Government intelligence estimates of Soviet tests have long been adjusted to take this into account, experts have questioned whether the adjustment factor was large enough.

Officials said the question of changing the United States estimating procedures has been under review and study for years.

NEW STUDIES COME TO LIGHT

The issue came to the fore again last year after several new studies.

Last Oct. 18, a panel of scientists selected by the Defense Advanced Research Projects Agency prepared a classified report that concluded that Government's method for estimating the yield of Soviet explosions was based on faulty assumptions.

The eight-member panel recommended a change in procedures that would lower the estimates.

The panel's report was submitted in late October to the Joint Atomic Energy Intelligence Committee, which issues reports on the size of foreign nuclear explosions. The committee is made up of members from the military services and intelligence agencies.

SECOND STUDY ADDS SUPPORT

Adding support to the scientists' recommendation was a separate study, also completed in October, that was overseen by the Air Force Technical Applications Center, which operates a system of seismic stations to monitor Soviet tests. This study agreed with the finding of the military research agency report.

On Dec. 17, the Joint Atomic Energy Intelligence Committee recommended that the C.I.A. adopt the advice in the report commissioned by the research agency. Official said the Defense Intelligence Agency disagreed, but was overruled.

The new C.I.A. procedure will be used to estimate the size of explosions in the Shagan River area of Semipalatinsk, where the Soviet Union conducts its largest nuclear tests. Officials said they expected the new estimating procedure to be applied to the next Soviet test in this area. The Soviet Union has not held a nuclear test since last summer, when it declared a unilateral moratorium on tests and asked the United States to join in a total test ban.

What the new procedure means about past Administration allegations about Soviet cheating is unclear.

REAGAN SIGNS DIRECTIVE

At the time the Administration prepared its report to Congress charging Soviet arms control violations, President Reagan signed a National Security Decision Directive, NSDD-202, that asked for a report on how the new method would reflect on past United States charges of violations by the Soviet Union.

This is the report that has not been completed, and officials are divided about whether the Russians have been violating the treaty.

Officials said applying the new method retroactively would still leave about a dozen Soviet tests that appear to be above the limit, although one official said that three or four of these exceeded the limit enough to warrant special concern.

The new procedure also suggests that the largest Soviet blast since the signing of the threshold treaty in 1974 was no higher than 250 kilotons. The Administration has previously said that the Soviet Union has conducted a test that was greater than 300 kilotons.

VIOLATIONS STILL "LIKELY"

One Administration official said the new data still point "in the direction of a likely violation" and noted that the Administration qualified its charges against the Soviet Union.

But another official said the change in the estimating procedure would significantly undercut the charges.

He said that given the uncertainty involved in seismic measurements, it was usual to expect some Soviet tests to appear to exceed the 150-kiloton limit. He added that some American tests that are under that limit may also appear to the Soviets to exceed the limit.

A spokesman for the Arms Control and Disarmament Agency said the agency was "not in a position to put forward any official agency view on this matter at this time."

SOME LONGSTANDING QUESTIONS

While officials familiar with the C.I.A. decision declined to be quoted on the record, other experts have openly supported the view that some estimates of the yield of Soviet tests have been too high.

Roger Batzel, the director of the Lawrence Livermore National Laboratory, in California, said in written testimony to Congress yet to made public that the Soviet Union might be complying with the treaty.

"Based on our assessment of the relationship between yield and seismic magnitude for the Soviet test site and the pattern of Soviet testing," he said. "We have concluded that the Soviets appear to be observing a yield limit. Our best estimate of this yield limit is consistent" with the threshold test ban. "However," he added, "the seismic data are subject to considerable statistical uncertainty."

That view differs from officials at the Los Alamos National Laboratory, in New Mexico, who have told Congress that verification of the threshold treaty is highly uncertain.

But a retired admiral, Sylvester R. Foley, Jr., the Assistant Secretary for Defense Programs at the Energy Department, which oversees nuclear testing, said in an interview that he tended to agree with Mr. Batzel's assessment.